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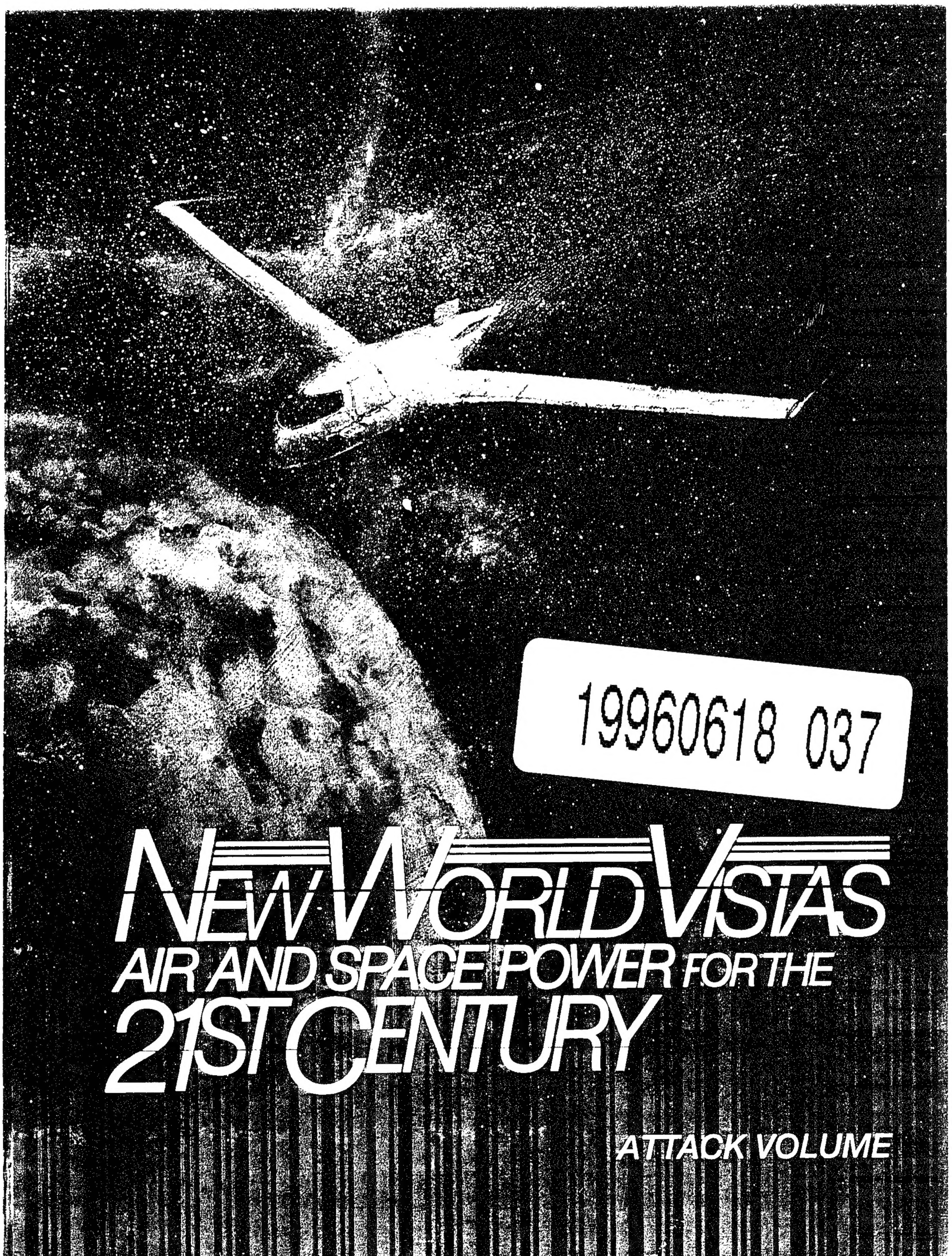

NEW WORLD VISTAS
AIR AND SPACE POWER FOR THE 21ST CENTURY

ATTACK VOLUME

NEW WORLD VISTAS
AIR AND SPACE POWER FOR THE 21ST CENTURY

ATTACK VOLUME

This report is a forecast of a potential future for the Air Force. This forecast does not necessarily imply future officially sanctioned programs, planning or policy.

Overview

Shaping the Air Force to meet the needs of the future is a daunting undertaking. In the face of grave geopolitical uncertainties, defense planners must define with the greatest possible precision a set of military capabilities that will allow the United States to prevail in a broad range of possible scenarios. Planners must also propose a path for acquiring those capabilities—a task that is complicated by the difficulty of formulating innovative concepts that capitalize on existing or emerging technologies and by the declining availability of resources.

An Operationally Oriented Approach to Defining Required Capabilities

In the past, the planning process was often heavily dependent on predictions about the likely future state of the world. While this was an acceptable approach when the enemy was well defined and well understood, it is less appropriate in today's environment. Therefore, the *New World Vistas* Attack Panel, charged with defining operational capabilities that would enable the United States Armed Forces—and particularly the Air Force—to conduct any mission, meet any contingency, dominate any battlefield, and win any war, adopted a somewhat generic approach to its mission. That is, it began by specifying certain "umbrella" prerequisites for achieving decisive military victory:

- The commander is skilled in the operational art of war
- The commander knows the capabilities, activities, and intents of the enemy; and he denies the inverse
- The victor dominates the battlefield and controls the operations of all enemy forces—land, naval, air, and space

Tasks, Concepts, Capabilities, and Systems

The Attack Panel defined the operational tasks required to control enemy operations. Among those identified, the following were deemed most crucial.

- Project power globally
- Provide dynamic planning and execution control
- Counter weapons of mass destruction: possession, delivery vehicles, and effects
- Achieve information dominance
- Counter invading armies
- Counter mobile, time-critical targets
  - Emitting radars
  - Firing artillery
  - TELs

The panel then formulated end-to-end operational concepts to accomplish each of the tasks. These concepts are summarized within the following categories:

- *Information Dominance.* In support of the operational doctrine of a dynamic planning and execution control, it is essential to gather information, assess that information, make decisions, and act in near-real-time under combat stresses. This translates to integrated functioning of sensors, processors, and communications that provide commanders, controllers, and shooters with the right information at the right time. It is equally important to disrupt the enemy's command-and-control processes and to deny him the ability to gather information about U.S. forces and activities.
- *Absolute Air Superiority.* In order to apply air power, the United States must have an assured ability to defeat hostile airborne and ground-based air defenses and to operate at will anywhere in the battlespace. This capability entails destruction or neutralization of enemy systems before they can act, along with the development of systems that combine signature control and countermeasures to defeat any surviving threat.
- *Persistent Presence.* Closely allied to air superiority, multiple operational concepts are well supported by a capability to maintain continuous observation and weapon delivery over and/or adjacent to an area of operations. Both airborne and spaceborne platforms can contribute to this presence, which allows development of time histories and locations of enemy activity, synoptic coverage of the battlespace, and rapid responses to time-critical situations.
- *Near-Instantaneous Strikes.* Engagements such as boost phase intercept of TBMs, suppression of mobile artillery, and neutralization of surface-to-air missiles are extremely time critical, often demanding that lethal energy be delivered within seconds to minutes of a triggering event such as a launch detection. Speed-of-light weapons and hypersonic missiles are among the system concepts that may contribute to the ability to prosecute such targets within these stringent timelines.

The panel also identified systems capable of providing substantial, perhaps revolutionary, increases in operational capability, including:

- An information system for dynamic planning and execution control
- An "invisible air vehicle" for attack and surveillance that can persist over enemy territory
- Speed-of-light weapons
- A nonexplosive electromagnetic weapon for disabling enemy radio frequency (RF) sensors
- Small, precise, tailored-effects weapons
- A bistatic radar system for battlefield use
- Lightweight, affordable, launch-on-demand battlefield surveillance satellites
- Next generation systems to replace AWACS, JSTARS, and ABCCC
- A global-range transatmospheric aerospace vehicle for strike and reconnaissance

Throughout the analytical process, the panel was mindful of three important goals. The first was to emphasize innovative ways to accomplish the anticipated operational tasks that will confront airpower in the next century. Innovation often leads to improved efficiency and swifter accomplishment of operational tasks. Gains in both of these areas will be crucial as the U.S. military strives to meet the challenges posed by severely constrained forces and resources.

The second goal was to seek concepts with high potential for capitalizing on commercially developed technologies. The third was to fully acknowledge the reality that future applications of air power will involve the use of joint and coalition forces.

The Overarching Concept: Dynamic Planning and Execution Control

The true potential of future forces will not be realized unless there is clear attention to the matter of command and control, which comprises three principal activities:

- *Force Managers at the Operational Level.* Inputs to force management include information about the desired campaign objectives, the availability and capability of forces, and the capability and intent of the enemy. In the case of air power, the output is the air tasking order (ATO) that assigns designated assets (aircraft) to stated missions (tasks) and to certain mission controllers. The process of converting input to output is the "operational art" of war. The panel strongly recommends increased attention to the realistic training of commanders in this somewhat elusive art.
- *Mission Commanders at the Tactical Level.* Mission commanders receive input from force commanders about the missions that must be accomplished in a given time period and the assets assigned for that purpose. The output at this level is explicit instructions to the engagers. These instructions include: (1) the rules of engagement; (2) a determination regarding which players are to engage which enemy units, and when; and (3) general instructions. The panel concludes that, to effectively convert inputs to outputs at this level, commanders must be thoroughly rehearsed in battle at the tactical level.
- *Engagers at the Engagement Level.* Engagement begins with a triggering event and ends when the target is killed or neutralized or the attack is terminated. The time from beginning to end may be a matter of seconds. The players must learn how to interact reliably in this intense, time-constrained, and likely highly-automated environment. The panel believes that considerably more attention should be paid to these interactions, and it suggests that facilities and field exercises be dedicated to this purpose.

Areas for Increased Air Force Attention

The Attack Panel recommends considerably increased focus and effort by the Air Force in the following areas:

Operational Concepts

Increase attention to and allocation of resources for concept development—i.e., the formulation of end-to-end integrated operational concepts to accomplish stated operational tasks. This undertaking must be based on an explicit and common definition of the operational tasks to be performed, as passed down from the highest levels of Air Force command. The process should be continuous to allow operational concepts to be updated in response to emerging conditions, rather than being generated sporadically in response to perceived shortfalls as is currently done. Without new and innovative concepts for accomplishing stated tasks, the effort to shape the 21st century Air Force will lack the fuel for change.

C² Training and Rehearsal

Improve the capability to exercise players at all levels of command and control. The exercises would occur at the levels shown below and would include training, development of tactics, evaluation of concepts, and rehearsal of scenarios.

- Strategic level: Train and rehearse senior members of the National Command Authorities (NCA)
- Operational level: Train force managers (combatant commanders)
- Tactical level: Train mission commanders (controllers)
- Engagement level: Train observers, engagement controllers, and shooters to interact within time-constrained engagement loops

Such exercises will also provide a means of evaluating basic operational concepts.

Dynamic Planning and Execution Control

Architecture

Develop and enforce an operationally oriented architecture for information systems, an architecture based on providing timely, accurate, integrated information to support commanders at all levels. Above all, this architecture must operate within the engagement timelines of dynamic planning and execution control and must meet the requirements of joint and coalition warfare. Major progress toward such an architecture is possible in the very near term using existing systems supplemented with commercial technologies and products.

Systems are required that can support decisions by bringing to bear all relevant information, including fusion and presentation of current and historical data from all sources. Data includes 2D and 3D imagery, target tracks, terrain, and intelligence. Also required are robust, secure communications channels among collectors, decision makers, and shooters. These must be transparent across the Services and coalition forces; standardization and interoperability are imperative. Our systems must recognize and reject both disinformation inserted by an enemy and poor-quality information from our own sources before they can degrade support to decision makers.

Without a determined effort to manage the generation, distribution, storage, fusion, and presentation of information to support timely decision making, the Air Force of the 21st century

will be data rich, information ragged, and decision poor. The Air Force should designate a senior official to establish an operationally oriented architecture for such an information system and enforce its provisions in system acquisition and employment.

Surveillance

Develop high-altitude unmanned air vehicle platforms with characteristics that will allow them to persist over enemy territory even in the presence of sophisticated integrated enemy air defense systems. (That is, they must be essentially invisible.) Such platforms are required to maintain a continuous presence for surveillance of a designated area or attack of time-critical targets.

Begin development of lightweight, affordable, launch-on-demand surveillance satellites. These satellites could provide supplemental coverage of areas of long-term interest and enhance the U.S. response to contingencies.

Begin development of passive radar surveillance platforms—e.g., using bistatic radar with an illuminator on a large aircraft in standoff orbit.

Begin development of a common airborne platform to perform standoff air and ground surveillance and dynamic planning and execution control using modular suites of mission equipment. Standoff surveillance modes include radar and all forms of RF signal intercept. Command and control functions include coordination of air, ground, and sea forces, particularly in environments such as littoral warfare. The manned platform would interface with unmanned platforms carrying sensors over the battle area. Such an airborne platform could perform various subsets of the functions now addressed by AWACS, JSTARS, Rivet Joint, and ABCCC for the Air Force. It might also address the functions of Advanced Quick Look/Guardrail Common Sensor for the Army and E-2C and EP-3E for the Navy. As appropriate, the common platform could be used for other in-theater real-time information management functions such as the psychological warfare functions performed by Volant Solo.

Weapons of Mass Destruction

Pre-employment Phase

Develop integrated concepts for neutralizing weapons of mass destruction in their pre-employment phases. This includes the warheads themselves and the facilities used in their development, production, and storage. The concepts must especially address the problems of detecting concealed facilities and of preventing the hazardous materials from being released into the environment as a result of the attack.

Boost-Phase Intercept

Develop concepts for intercepting and destroying enemy ballistic missiles during the boost phase (at least prior to fractionation), concentrating attention on those concepts using unmanned platforms that can persist in the area of the anticipated launch areas. Such platforms could employ hypersonic interceptor missiles that can attack in all directions from the carrier platform, or they could employ high-power directed-energy weapons.

Cruise Missile Intercept

Focus attention on: (1) theater air defense BMC^3 systems that can detect and initiate the engagement of LO cruise missiles in clutter and (2) advanced air-to-air missiles that will be effective against LO cruise missiles operating in clutter at low altitude and against other stressing targets. These missiles should be long range, employ multimode guidance, have advanced counter-countermeasure capabilities, and have a high P_k using advanced-propulsion and explosive-warhead technologies.

Survivability

SEAD

Continue an integrated effort for SEAD, in the context not only of allowing non-LO platforms to penetrate close to their targets but also of allowing these platforms to persist and survive over enemy territory.

Place increased emphasis on speed-of-light weapons as a means of neutralizing time-critical targets. This applies particularly to a SEAD concept where the goal is to keep SAMs on their launchers by neutralizing acquisition radars before they can establish track—a matter of a few seconds.

These weapons might be high-power microwave weapons that damage or upset electronic circuits by brute force from substantial standoff distances. They could also be weapons that interfere with circuit logic. The latter type of weapons may operate at much lower power levels, thus allowing speed-of-light attacks from moderate-sized weapon platforms such as modestly sized UAVs.

Countermeasures

Focus on end-game countermeasures effective against antiaircraft missiles, especially those with imaging focal-plane-array IR seekers. These may include both short-range directed energy weapons to disable key components of the attacking missile and short-range antimissile missiles with hit-to-kill guidance derived from ballistic missile defense technologies.

Satellite Operations

Provide increased focus on concepts to deny certain operations of enemy or civil satellites if being used by the enemy for hostile purposes. This could include using satellites to inspect and/or neutralize enemy satellites at close range. Neutralizing may operate at different levels, from the temporary disruption of satellite functions to the permanent disabling or destruction of the satellite.

Survivable SOF Aircraft

Begin development of an aircraft capable of inserting and extracting Special Operations Forces in high-threat areas and of conducting rescue operations in the most stressful circumstances. Survivability is paramount; covertness is required. Specifically indicated is an aircraft that is low observable, has long range at high subsonic speed, and is capable of STOL and VTOL/hover at the destination.

Global-Range Aerospace Plane

Establish the technical feasibility of an unrefueled global-range aerospace plane to perform reconnaissance and strike functions anywhere on the globe in response to fast-breaking events. For example, investigate the AJAX concept proposed by the Scientific Research Enterprise for Hypersonic Systems in St. Petersburg, Russia.

Improved Air-to-Ground Munitions

Develop and procure air-to-ground munitions that are affordable, small and precise (day/night/adverse weather). These developments should exploit state-of-the-art technologies to produce the desired conventional and/or unconventional effects—"tailored" effects—in weapons sized several times smaller than those in the current inventory.

Summary

The Attack Panel's analysis, starting from basic operational considerations, has resulted in the identification of new weapon system concepts and the improvements in air power capability which those concepts would deliver. These are concisely summarized in Tables 1 and 2.

Table 1 relates priority Air Force missions to new weapon systems, which are in turn categorized as "revolutionary" or "other." Table 2 identifies crucial military capabilities, indicates the current state of the art, and specifies desired mid- and long-term objectives for each capability.

Table 1

	Priority Air Force Tasks												
	Critical Tasks							Other Tasks					
	Establish dynamic planning and execution control	Counter WMD	Counter mobile SAMs	Deny info to enemy	Counter invading armies	Project power globally	Suppress hostile artillery	Counter TBMs	Counter cruise missiles	Defeat enemy air forces	Prohibit use of civilian facilities for military purposes	Nuetralize hostile space operations	Conduct other operations
Revolutionary													
"Invisible aircraft"		X	XX		X					XX			
Bistatic radar	X		XX		X				X	X			
RF weapon		X			XX			X			X		
Lightweight satellites	XX		X	X		X	X		X	X	X		XX
Follow-on STARWACS	XX	X	X		XX	X	X	X	X	XX	X		X
Speed-of-light weapons		X	X				X	XX				X	
Global-range aerospace plane	X	X			XX	XX		X		X			
Info systems for dynamic battle C^2	XX	X	X	X	X	X	X	X	X	X	X	X	X
Other													
Hypersonic weapons		X	X		X		X	XX	X				
Penetrating/containing PGMs		XX		X	X		X	X	X				
LO SOF aircraft	X	XX		X		X				X	X		XX
Highly survivable attack platforms		X	XX		X	X		X		X			
Space-object surveillance from space	X		XX		X							XX	
Decision training/rehearsal	XX	X			X	X				X	X	X	X
Nuclear, biological, chemical sensing	X	XX						X			X		X
Improved air-to-air missiles					X				XX	XX			
Improved air-to-ground munitions		XX	X		XX	X	XX	X		X	X		X
High-altitude endurance UAVs	XX	X	X	X	X		X	X			X		X
Responsive, efficient logistics systems	X	X	X	X	X	X	X	X	X	X	X	X	X

Blank = Capability unrelated to task
X = Capability that supports task
XX = Capability critical to task

Table 2 Availability of New Capabilities/Systems

Capability	Current	Mid Term (5 to 15 years)	Far Term (10 to 30 years)
"Invisible aircraft" - Persistent over battlefield	- Limited stealth, some signatures	- Defeat IR threat through signature control and advanced IRCM - Defeat current air defense systems - Fly prototype	- Conclusively negate advanced air defenses
Bistatic radar - Passive targeting	- Tech demo	- Add bistatic modes to inventory aircraft - Field basic illuminator	- Operate bistatically with any available illumination
RF weapon	- Tech demo - No fielded systems	- Field weapons to neutralize enemy electronic systems - Field "pushbroom" on airborne platform	- Paralyze enemy information processes
Lightweight, affordable satellites - Launch-on- demand surveillance satellites	- Lab demo - Commercial development	- Field affordable space surveillance launch-on demand	- Develop and field dense, replenishable, on-demand constellations of affordable multifunction satellites
Follow-on AWACS/JSTARS - Battlefield control	- E-3 and E-8 - Lab demos, P^3I programs	- Complete major upgrades. especially to AWACS and JSTARS - Integrate additional DPEC functions with AWACS/JSTARS	- Develop and field integrated air/ground surveillance-and-control platform
Speed-of-light weapons - Rapid destruction	- ABL tech demos - HPM tech demos	- Field ABL - Field mid-high power RF weapons	- Develop and field long range, high-power DE weapons family
Global-range aerospace plane - Rapid response	- Critical demos (NASP Legacy)	- Fly prototype TAV (< global range, > Mach 10)	- Field multimission, global recce/strike vehicle
Information system for dynamic planning and execution control (DPEC)	- Multiple stovepipes - Marginal air-to-air networks (Link 16) - Initial platform/ground LANs	- Establish architecture - Field COTS/NDI/ improved systems - Field first-generation DPECIS	- Develop and field full DPECIS (data bases, processing, human/ machine interlaces, etc.)
Hypersonic weapons - Rapid strike	- RVs only	- Field Mach 5-6 missiles - Field ABM interceptor	- Field scramjet 500-700 nm standoff
Penetrating PGMs - Weapon	- Explosive penetrating PGMs	- Field first-generation nonexplosive Warheads	- Develop and field intelligent nonexplosive, multiple-mechanism warheads
SOF aircraft - Penetrate	- Existing SOF aircraft - CV-22 - LO technology	- Field the aircraft	- Field improved aircraft

Table 2 Availability of New Capabilities/Systems (continued)

Capability	Current	Mid Term (5 to 15 years)	Far Term (10 to 30 years)
Surviving platforms	- JAST weapon system concept programs - LO technology - F-1 17/B-2 - F-22 EMD program	- Field effective IRCM - Field self-defense missiles compatible with countermeasures dispensers	- Defeat all air defenses
Space object surveillance from space	- Ground-based systems	- Field on-orbit surveillance system	
Decision training and rehearsal system	- MS&A technology - SWC, NTB, TACCSF, Blue Flag, wargaming	- Create high-fidelity national decision rehearsal facility	
Nuclear, biological, and chemical sensing	- Counterproliferation programs - Tech demos	- Field multi/ hyperspectral sensors for chemical species and dispersed bioagents	- Field highly sensitive detectors for all known chemical species and bioagents
Improved air-to-air missiles - Strike	- AMRAAM - AIM-9	- Field AIM-9X and P³I AMRAAM	- Develop and field long range (30nm) counter LO, counter CM, high-P_k, multi-mode guidance AAM
Improved air-to-ground munitions - Strike	- LGBs, GBUs, dispensers, submunitions - Tech demo	- Field JDAM, JSOW, wind- corrected dispenser - Field advanced explosives (2-4 x bang per lb) tailored warhead effects	- Develop and field autonomous- powered standoff munitions with flexible warheads and advanced explosives (3-10 x bang per lb.)
High-altitude endurance UAVs - Surveillance and targeting	Tier 2+/3- program - LO technology	- Field multimission modular sensor payloads >80,000 ft alternative propulsion	- Field full concept
Responsive, efficient logistics systems - World-wide response	- Manual, stovepiped systems - Costly and excessive inventory	- Field full concept	
Global delivery aircraft	- C-5B, C- 17, CRAF 747	- Field C-17B	- Develop and field global-range aircraft

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1.0 Introduction

1.1 The Changing Face of Conflict

For over forty years, the United States confronted a monolithic threat against which it evolved a highly focused military strategy. Today, U.S. force structure is shrinking, and potential adversaries are many and diverse. The dividing line between using military forces to underwrite national security strategy and using them to conduct other types of operations grows increasingly blurred.

Major wars are still possible, but most conflicts are likely to be small. Irregular forces—e.g., hybrids and militias—may be prominent. Combatants and noncombatants will sometimes be intermingled, with resulting complex rules of engagement. Political guidance to the military may change dramatically as events unfold under real-time, world-wide scrutiny. A requirement to accomplish military objectives swiftly, with minimum loss of life on both sides, argues strongly for the employment of unconventional (i.e., "nonlethal") weaponry.

The U. S. military can expect to be increasingly called upon to suppress violence and restore order abroad. The end of the Cold War has uncorked long-festering problems and spurred independence movements based on nationalism, ethnicity, and religion. The continued growth and urbaniztion of populations in developing nations is straining those countries' infrastructures. In addition, the spread of democracy and the burgeoning flow of information are undermining existing social orders in many countries. All over the globe, people are beginning to demand a voice in government, and they can readily communicate with like-minded individuals and groups worldwide. Thus, hierarchical nation states are being gradually transformed into world-wide networks of interests.

1.2 The Information Revolution

The information revolution provides potential "combatants" with direct access to a global audience and—through the Internet, CNN, and fax machines—with the ability to influence international and domestic public opinion. Likewise, advances in information sciences are increasing the political and technological sophistication of such groups. For example, future adversaries may transmit and receive intelligence information over common carriers such as the Internet. They may also manipulate, and even create, images of conflict for propaganda purposes.

In the recent past, nations were required to make substantial investments to gain access to imagery and communications services that can now be purchased by individuals. Thus, for a relatively modest investment, small political entities and relatively "poor" and technologically undeveloped nations can have situational awareness heretofore the domain only of superpowers. The implications are staggering. Movement of U. S. military forces can be easily monitored, and targeting of those forces and of military installations can be done with high precision. It is now incumbent on the United States to develop a policy regarding the temporary or permanent denial of information and/or access to information to any potential adversary.

1.3 Information and the Art of War

World and domestic opinion exercise enormous leverage on the willingness of the United States to engage in military conflicts or continue the involvement of its forces in such conflicts.

Therefore, the use of armed forces in any endeavor must be swift and decisive with minimum loss of life on both sides. In many cases, decisions will have to be made swiftly; and all levels of command, from the NCA to flight leads, must be provided with timely and unambiguous information, as well as with highly sophisticated decision aids.

Closely aligned with the information issue is the matter of command. Decisions are made at the operational level about how to allocate scarce resources among a range of tasks and missions. These decisions depend heavily on the commanders' grasp of the operational art of war in the presence of the information in hand. Without a full appreciation of this interrelationship, the United States military may find itself data rich, information ragged, and decision poor. Thus, enhancement of commanders' skills and capabilities must take its place as an integral feature of military dominance in the next century.

1.4 Approach

Despite the rapid changes taking place throughout the world, indeed perhaps because of them, it is crucial not to lose sight of the national military objectives of the United States. At the *operational level*, the common missions of the United States Armed Forces are to:

- Protect and defend U. S. interests that affect its security and well being by projecting combat power to deter and, if necessary, to decisively defeat aggressors
- Promote stability and deter aggressive acts by maintaining an overarching global presence
- Promote other enduring U. S. interests and values through the conduct of peace operations and humanitarian relief

Against this complex backdrop, the Attack Panel endeavored to define a path the United States Air Force could follow to assure its contribution to U.S. military dominance in the 21st century and beyond. Though we recognize that we cannot forecast the future, we feel confident of our ability to predict key military tasks the armed forces of the United States will be asked to perform, particularly those in which air and space power play a primary role. We assert that the tasks we have identified are enduring and that they will remain relevant no matter what direction the future may take.

1.5 Organization of this Report

In Chapter Two, we list the key operational tasks that will be required of the military services in the next century. Chapter Three introduces the concepts for accomplishing those tasks. The concepts are described in greater detail in Appendix E.

Chapter Four considers specific systems and technologies that support each operational concept. These functional capabilities fall into the "must-have" category; without them the concept cannot be realized. Technologies that are considered "revolutionary" are further explored in Chapter Five.

Finally, in Chapter Six the panel makes broad recommendations for actions the Air Force must take to ensure its ability to meet all theater air requirements of the future.

2.0 Vistas of New Capabilities

2.1 Themes

The Attack Panel's vision of *New World Vistas* centers on two key themes. The first is that the U.S. military must dominate the battlefield completely and decisively. It must possess the capability to conduct combat operations rapidly and to sustain high-intensity operations, while at the same time constraining the enemy to operate at low intensity or, preferably, not at all. The second theme is that the military must be able, at the direction of higher authorities, to conduct special, sensitive missions reliably and without mistakes. Such missions may include humanitarian aid and relief operations.

In the main, the operational tasks are familiar. The challenge is to find ways to accomplish them faster and more decisively, with fewer collateral effects and fewer forces, and across all scenarios and environments.

Consistent with the above themes, the Attack Panel has defined a set of key tasks, grouped into three main categories, that frame the major operational capabilities needed in the 21st century.

2.2 Dominating the Battlefield

At the operational level, it is essential that U.S. military forces be constantly aware of activities of the enemy and that they deny the inverse. In the presence of information dominance and exercising brilliant command and control, we undertake the following tasks:

- If enemy forces move on the ground in forbidden areas, ensure that they "die"[1] before they reach their objective.
- If enemy forces occupy territory or bases in forbidden areas, force them to leave or promptly destroy them.
- If enemy aircraft are deployed on or operate from forbidden bases, destroy the bases and aircraft.
- If enemy aircraft or UAVs[2] fly in forbidden areas, ensure that they die[1] before they can accomplish their mission.
- If enemy ships or submarines operate in forbidden waters, ensure that they die; if enemy ships or submarines are deployed in forbidden ports, ensure that they die.
- If enemy spacecraft operate in forbidden ways, neutralize them.
- If the enemy conducts adversarial operations at spaceports, neutralize the spaceports.
- Quarantine noncombatant facilities, including schools and churches, being used for forbidden purposes.

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1. The word "die" is used generically and includes both nonlethal neutralization and physical destruction, where appropriate.
2. In the Summary Volume and other Panel reports, UAVs are also referred to as Uninhabited Combat Air Vehicles (UCAVs), Uninhabited Reconnaissance Air Vehicles (URAVs) and Unmanned Tactical Aircraft (UTAs). In this volume, UAV and UTA are in the same family as UCAVs and URAVs.

- Neutralize enemy air defense batteries before they can complete an engagement on friendly aircraft or UAVs. Ensure that operators of enemy air defense batteries that are engaging targets die. They cannot "shoot and scoot."
- Ensure that operators of enemy ground combat weapons (rifles, artillery, mortars) that fire rounds into a specified area die. They cannot successfully shoot and hide.
- If a designated hostile nation produces weapons of mass destruction (and associated delivery systems), identify and destroy these weapons systems.
- Destroy/neutralize (over enemy territory) all ballistic missiles launched from enemy territory or other designated areas prior to their dispensing submunitions.
- Destroy enemy cruise missiles launched from designated areas before the missiles can exit those areas.
- Kill enemy operators that launch offensive missiles, and kill the launcher.

2.3 Conducting Special Sensitive Missions

- Rescue U.S. nationals before they can be detained by foreign nations or groups. If this is not possible, rescue them after they have been detained.
- Evacuate groups of U.S. nationals and other specified groups threatened by hostilities and disasters. Defend embassies and other facilities.
- Deter/prevent/punish terrorism, especially nationally sponsored terrorism.

2.4 Providing Relief

- Conduct humanitarian relief operations *in the presence of hostile fire.*
- Provide relief services rapidly in response to disasters and establish an infrastructure to sustain relief operations.

2.5 Important Insights from these Vistas

The United States must demonstrate to all would-be enemies that it will respond to aggression quickly and decisively; that it can prevent or neutralize the operations of enemy units before these operations can cause us harm; and that it can "control" the operations of stated forces in stated areas at stated times in all environments. The U.S.military should seek to impart a sense of fear, coercion, deterrence, or paralysis down to the enemy operator level. It should also strive to make enemy operators fear the consequences of carrying out assigned missions or functions.

To accomplish the above tasks, the Attack Panel sought to specify operational concepts that are robust and relevant across the types of conflicts in which U.S. forces may be engaged and across the environments in which these forces may operate. These operational concepts focus on "engagement/execution control"—the intense, time-constrained interaction among several players, including sensors, situation assessors, controllers, shooters (platforms and weapons), and assessors of the results of U.S. actions and enemy responses.

3.0 Operational Concepts to Achieve *New World Vistas* Airpower Capabilities

3.1 Approach

To bring a concrete, warfighting focus to our consideration of the technology future of the Air Force, the Attack Panel examined a set of stressing operational tasks; and we explored concepts for effective, affordable, innovative ways to accomplish those tasks. We selected the tasks for analysis from the results of an examination of essential missions of the armed forces in which air power plays a prominent role. They represent the full spectrum of ways in which air power can be expected to provide critical capabilities to meet the needs of the future.

Throughout the analytical process, the panel was mindful of three important goals. The first was to emphasize innovative ways to accomplish the anticipated operational tasks that will confront airpower in the next century. Innovation often leads to improved efficiency and swifter accomplishment of operational tasks. Gains in both of these areas will be crucial as the U.S. military strives to meet the challenges posed by severely constrained forces and resources. The second goal was to seek concepts with high potential for capitalizing on commercially developed technologies. The third was to fully acknowledge the reality that future applications of air power will involve the use of joint and coalition forces.

To give a sense of our analysis, the following paragraphs briefly describe the concepts we developed for five of the tasks. A detailed description of the full set of missions and tasks is contained in Appendix E. Table 3 presents selected key features of the full set. For each task, we defined the circumstances bearing upon the application of air power; the resources needed to do the job; and the information-gathering, assessment, and decision processes associated with successful prosecution of the war.

From our assessment of each task, we derived an operational concept and defined it in terms of sensors, weapons, platforms, and elements of dynamic planning and execution control. That information appears in Table 3. This tabulation of needs provides the Air Force with a basis for arriving at a prioritized listing of the areas where it can best invest resources to maximize its ability to deal with future demands for warfighting and for operations other than war—e.g., relief and rescue.

3.2 The Doctrine of Dynamic Planning and Execution Control

We defined the Doctrine of Dynamic Planning and Execution Control in order to provide an operational foundation for all of the operational concepts we examined. The doctrine has three components: force management, mission control, and engagement control.

Force Management

Force management is, in the first instance, a matter of apportioning forces to various broad mission areas or operational campaign objectives. For example, during a designated period of time—several hours to a day—the comander in chief (CINC) decides to apportion certain forces to various objectives: to enforce no-fly zones in one area, to hunt for transporter/erector/ launchers (TELs) of theater missiles in another, to engage in strategic attack, to interdict enemy land

forces, to engage in close air support (CAS) in support of a U.S. Army Corps, and so on. These allocations are performed in the context of making the best possible use of available forces, and they are crucially dependent on the commander's grasp of the operational art of war and its application to the campaign being undertaken.

A second aspect of force management deals with what forces are to be employed. This depends on the types of forces present and how many will be available from each force element within a given time. The numbers of available forces are not determined by the CINC. Rather, they are an input to his planning.

The CINC reveals his decisions and guidance about the weight of effort among broad mission areas. Based on this guidance, the Joint Forces Air Component Commander (JFACC) prepares the ATO, which defines (1) the aircraft—both strike and support—that will be available over time, (2) the armament on these aircraft, and (3) the mission controllers to whom particular forces will be assigned. The time constants in force management range from hours up to three or four days.

The ATO assigns the mission (task) for each aircraft but not necessarily the target. For example, the particular enemy aircraft an F-15 might engage (if any) is not known. What is known is that the F-15 pilot will be assigned to enforce a no-fly zone in an area to be designated by the mission controller to whom the F-15 is assigned.

Mission Control

This level of command controls the weight of effort within a particular broad mission area. For example, the ATO assigns F-15s to a broad mission area and to a particular mission controller (commander). The mission controller now assigns the F-15s to report to a certain controller in a particular Airborne Warning and Control System (AWACS) for engagement control. The time constants in mission control are minutes to hours.

Engagement/Execution Control

Engagement (or execution) control is the most stressing element of command and control. It begins with a triggering event. Thus, in the case of the "mission" of enforcing "no exit of ballistic missiles (boost phase intercept)," the triggering event is the launch of the enemy missiles. Our operational concept is to destroy the enemy missile prior to booster burnout.

In engagement control, the time loop from observation to assessment to decision to act is apt to be very short—a matter of seconds or, perhaps, minutes. The players (observers, assessors, controllers, shooters) are dedicated to causing a "kill" in seconds to minutes after the triggering event. The flow of information is "dedicated" to the control loop, which is generally highly automated. The only human interaction may be by exception—e.g., the mission controller changes the rules of engagement.

The platforms involved in accomplishing a designated task require one other type of information: threat warning. An external system is dedicated to this purpose, and it must also have time loops of a few seconds. For example, within a few seconds of a triggering event(s), the threat warning appears as an icon on the heads-up display of the F-15 engaged in the mission of enforcing no-flying in a particular zone. It is an important requirement that this information

is "pushed" to the cockpit and is limited to only what is critical and timely to mission execution: e.g., threat warning, weather changes, or a change in the rules of engagement.

Dynamic Planning and Execution Control is central to increasing the capabilities of air power. Increases in capability will stem primarily from the ability to collect, analyze, and use information to make critical decisions to engage enemy units quickly and decisively—in short, to maximize the effect on the enemy within the constraints imposed. Dynamic Planning and Execution Control bears importantly on the viability of all of the operations and concepts which follow. Certain functions are crucial: timely information; timely decisions; proper assignment of tasks to computers and automation; proper assignment of tasks to commanders, controllers, and operations; and proper synchronization.

3.3 Selected Tasks and Operational Concepts to Accomplish Them

3.3.1 Counter Weapons of Mass Destruction (WMD)

Much attention has been focused on countering the delivery mechanisms for WMDs, but the more urgent task is to determine the possession, manufacture, and movement of nuclear, biological, and chemical (NBC) materials and devices by opponents—who range from terrorists to rogue nations—and to counter the WMDs prior to their employment. Our concept is that U.S. forces will determine with high precision the location of NBC facilities and, upon a national decision that they represent a critical threat to U.S. interests, will destroy them without inadvertently disseminating hazardous materials.

This concept, illustrated in Figure 1, centers on sensing the unique signatures associated with NBC targets, and it involves major advances over current sensor capabilities. The concept requires a variety of sensors, including multispectral electro-optical (EO), imaging, radar, and signal intelligence (SIGINT); and it employs various specialized detectors on persistent/enduring platforms. These platforms include satellites, UAVs, and unattended ground sensors (UGSs) to detect and identify effluents and nuclear radiation and to gather all types of intelligence to characterize NBC facilities, which are expected to be buried or otherwise hardened.

When tasked to strike, U.S. forces will use penetrating weapons with precision guidance and kill mechanisms that destroy the contents without releasing them into the environment. If destruction is not possible, absolute containment is required. Those weapons will contain the means to send back information which, in conjunction with external sensors focused on the target during the strike, will permit accurate battle damage assessment (BDA). Control of the engagement is similar to that of other air-ground sorties, but it may involve special rules of engagement, especially in the case of preemptive strikes.

3.3.2 Counter Theater Ballistic Missiles (TBMs)

TBMs are a growing threat for hostile use of weapons of mass destruction. Our concept (Figure 2) is to prevent their launch or, if necessary, destroy them over enemy territory before warhead fractionation occurs—in other words, to put a "lid" on the opponent through which no missiles can escape. The concept begins with long-term surveillance with electro-optical imaging, ground moving target indication (GMTI), synthetic aperature radar (SAR), signals intelligence (SIGINT), and other sensors on satellites, UAVs, and on the ground, all of which will locate TBM facilities and track movements.

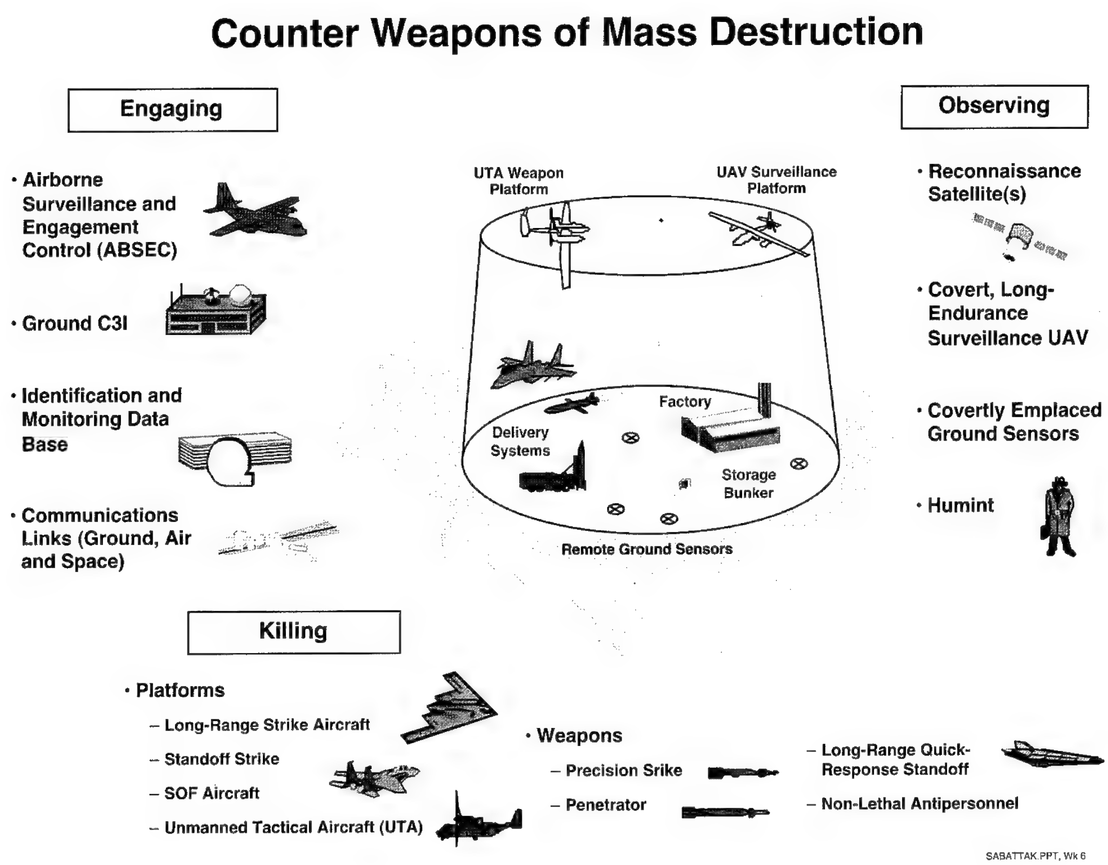

Figure 1

A preemptive strike against known launch sites will reduce the threat. Deployments and launch preparations will be detected with wide-area and focused surveillance; and weapons will be struck, whenever possible, before launch. Timelines for these engagements range from minutes to perhaps an hour and involve air-delivered precision guided munitions (PGMs) with both fixed and moving target guidance.

In the final extremity, when TBMs are launched, they will be detected and tracked with EO sensors and tracking radars. For those missiles that are launched, boost-phase intercept will then be accomplished with directed energy weapons or fast (≥ 4 km/sec) missiles. Engagement control must be real-time and on-scene, either on the observation or weapon platform or in the form of links to an off-site facility.

3.3.3 Counter Cruise Missiles

Cruise missiles are widely proliferated around the world, and this threat will increase over time. Many of these missiles are capable of delivering WMD, and some are equipped with

Counter Theater Ballistic Missiles

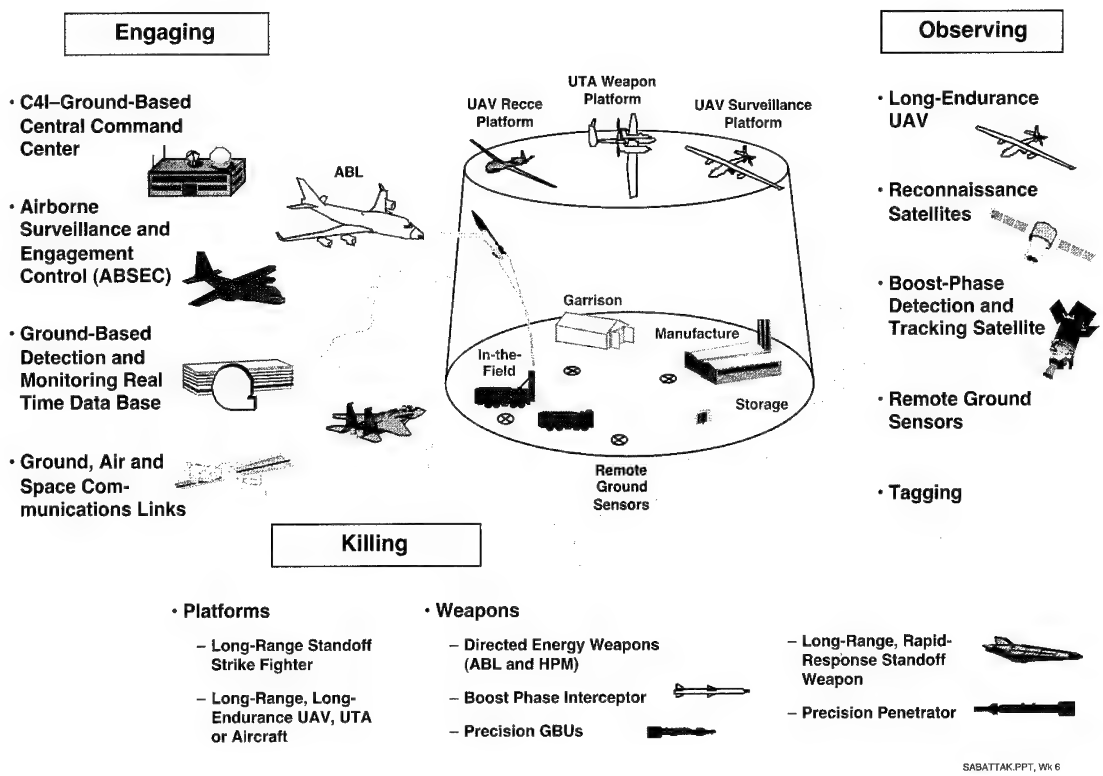

Figure 2

active and/or passive countermeasure systems. Most are inherently LO and can be made more so with elementary signature technology. When flying low in ground clutter, cruise missiles present an extremely difficult target. Success against them begins in our concept (Figure 3) with long-term surveillance of potential adversaries to monitor their possession and deployment of such weapons, intelligence to determine their characteristics, and continued surveillance focused on probable launch sites.

Both air-and rocket-assisted ground launchers can be detected, respectively, with wide-area air surveillance and missile launch detectors, while SAR/GMTI radars have the capability to detect runway takeoff. Counter-LO technologies will be needed to detect and track missiles in flight and vector interceptors. Our concept calls for destruction of missiles over the owner's home territory. The actual shootdown requires the same capability as any air combat with an LO opponent, including missiles whose seekers and warheads are effective against low radar and infrared (IR) signature targets. The engagement may be controlled from an airborne platform or from a ground control facility with the necessary communication links to sensors and fighters.

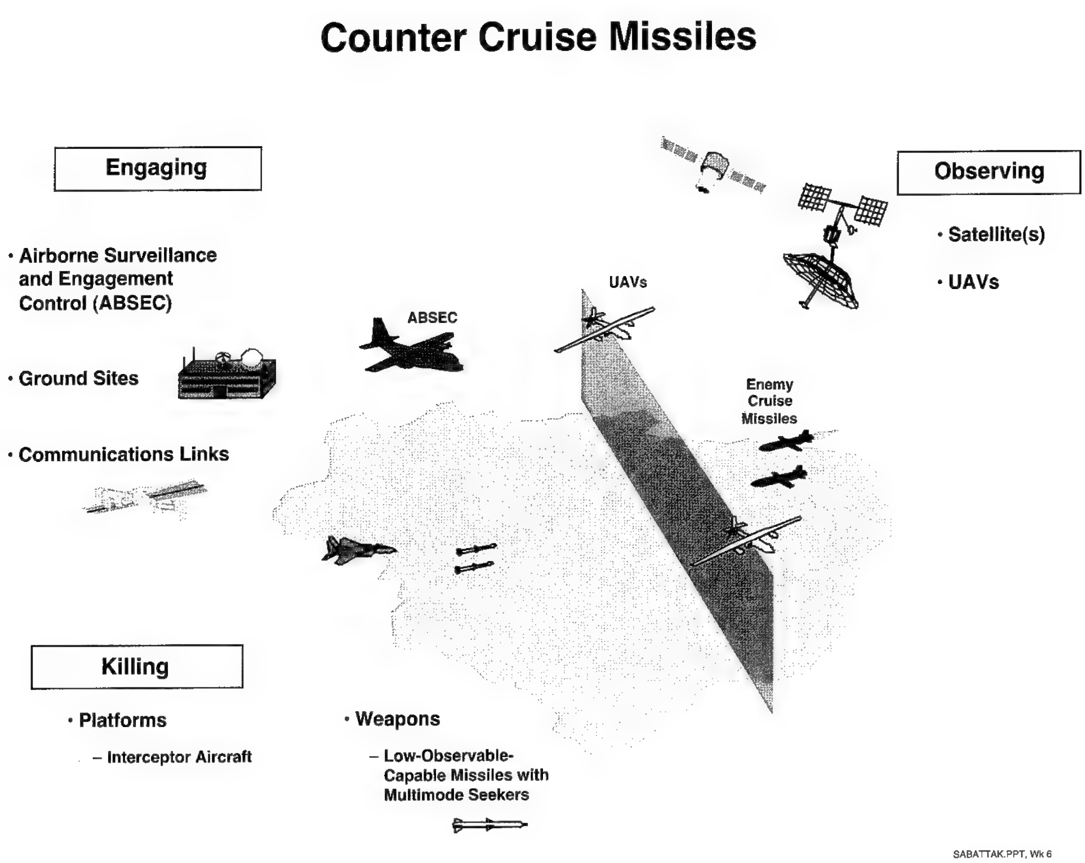

Figure 3

3.3.4 Suppress Enemy Air Defenses (SEAD)

The threat to friendly air assets is, and will remain, dominated in most scenarios by surface-to-air, rather than air-to-air weapons. Achieving complete air superiority demands that the enemy's defenses be neutralized,through destruction or functional disruption. In our concept (Figure 4), acquisition radars and known surface-to-air missile (SAM) and antiaircraft artillery (AAA) batteries will be destroyed in parallel as part of the preparation of the battlefield. Subsequently, any threat radar which paints a friendly aircraft will be killed before it can complete an engagement. Acquisition radars cannot establish a track for SAM batteries and will not hand off targets, and tracking radars will be neutralized before the engagement can be completed. This begins with precise geo-location and classification of all emitters, largely with sensors on UAVs, using decoys as appropriate to stimulate the enemy to radiate. Weapons can then strike sites that are not transmitting.

Once air operations begin, the same sensors provide real-time detection and location of radars which survived the initial preparation. This is now a time-critical engagement with a window of a few seconds to kill the radar before it can complete its function. The Air Force

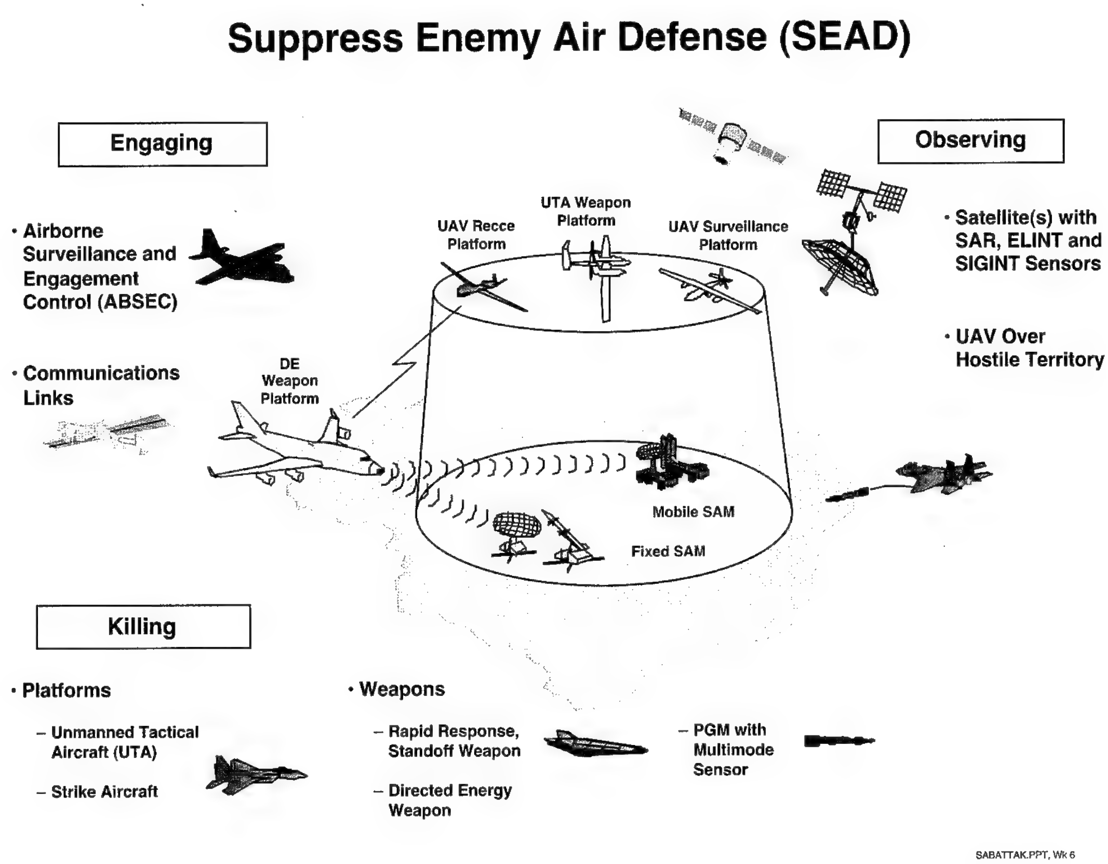

Figure 4

needs speed-of-light weapons to shorten the engagement loop–e.g., using high-power microwave (HPM) weapons on aerial platforms to disable, and possibly damage, tracking radars. In addition to such directed energy (DE) weapons, high-speed missiles with a variety of seeker modes—including antiradiation (ARM) and imaging guidance fired by on-station attack air vehicles—will be used for assured kill.

3.3.5 Suppress Hostile Artillery

Bosnia provides an example of a situation in which the United States must be able to enforce a cessation of hostilities by forbidding a hostile party to fire artillery, mortars, rockets, or any other large ground weapons into specified areas such as protected safe havens. U.S. forces must also be prepared to retaliate with swift, certain destruction against any violations. The essence of the task is the ability to precisely and unambiguously locate the unit which has committed the violation and deliver appropriate ordnance before the enemy can move. The sensing task is likely to be complicated by a cluttered, ambiguous background of terrain and civilian activity and to involve foliage and other camouflage, concealment, and deception (CCD) measures.

The risk of collateral damage may be high and its consequences severe. The enemy may use innocent bystanders as cover, thus requiring use of an incapacitating rather than a lethal weapon. Our concept (Figure 5) starts with comprehensive surveillance, comprising imaging and GMTI sensors supported by SIGINT and other sources, to build a time history of enemy movements and locations. Precise location of the weapon(s) to be struck may come from ground observers, focused sensors that defeat CCD, flash detectors, firefinder radars, and other sensors. Targets may be struck from on-station attack aircraft with PGMs, including unitary warheads and smart submunitions or with fast (perhaps hypersonic) cruise missiles. The controller for the engagement will likely be on an airborne ground target surveillance and engagement control platform such as the Joint Surveillance and Target Attack Radar System (JSTARS).

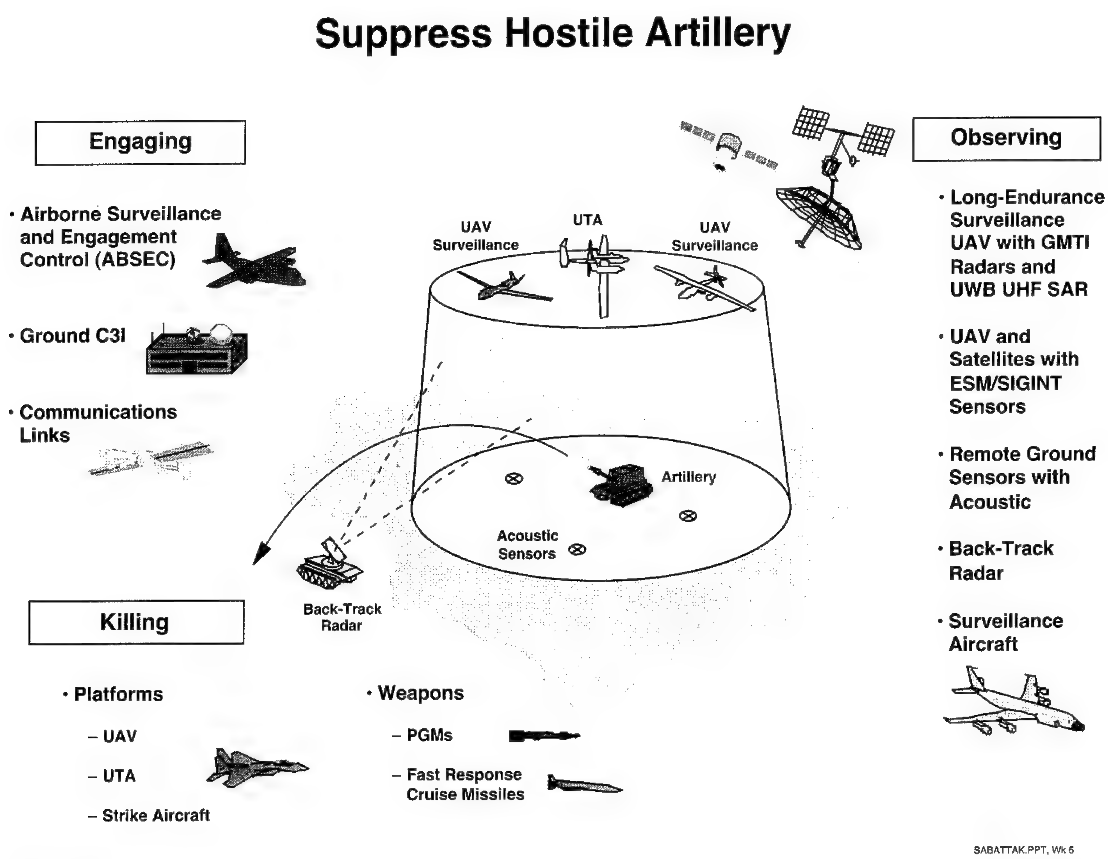

Figure 5

3.4 Summary of Selected Operational Concepts

We have elaborated operational concepts for selected tasks, including the five summarized in the text above. The key elements of these concepts in the areas of sensors and sensing platforms, weapons and weapons platforms, and dynamic planning and execution control (including those in Appendix E) are summarized in Table 3.

Table 3 Key Elements of Operational Concepts

Operational Task	Observing (Sensors/Platforms)	Engaging (Dynamic Engagement/ Execution Control)	Killing (Weapons/Platforms)
Counter weapons of mass destruction	• Real-time data base of NBC facilities • Covert monitoring, classification, and cataloging of emissions and activities • New sensors for unique signatures • Multispectral EO, imaging, SIGINT, or radar platforms, including UAVs, satellites, and UGSs	• Special rules of engagement, especially in cases of preemptive strikes - Covert strike capability - Protection of noncombatants	• Penetrating weapons with precision-guidance and kill mechanisms that neutralize NBC facility contents without releasing them into the environment • Weapons containing means to send back BDA information
Counter theater ballistic missiles	• Real-time data base of all suspected sites • Systems to sense critical threat-triggering event (e.g., missile launch and state vector) • Systems to maintain track of booster until engaged • Observation platforms—e.g., UAV that persists over enemy territory	• Time critical for boost phase intercept (50) seconds from triggering event to kill) • Automatic control Loop of sensor-to-shooter • Offsite engagement controller with enabling switch	• DE weapon that can kill at 200 km or interceptor that travels upward of 5 km/sec • UAV or UTA that can persist over enemy territory
Counter cruise missiles	• Intelligence data to confirm existence and determine characteristics of storage and launch sites • Surveillance/missile launch detectors to locate and verily employment	• Engagement control from airborne $C^3$1 platforms or ground sites	• Surveillance platform to acquire track and cue lighter attack with LO-capable radar missiles
Suppress enemy air defenses (SEAD)	• Real-time data base of all transmitters • Accurate observation of transmission and location of target • Sensor platforms that can persist over enemy territory	• Automatic sensor-to-shooter loop (no more than 2 seconds from triggering event to "Fire") • Offsite human operator with "guns-free" switch	• Neutralization of transmitter before it establishes track (15 seconds or less) • Speed-of-light weapons with kill ranges of >100 km • Weapons platform that can be in DE weapon range at time of triggering event

Table 3 Key Elements of Operational Concepts (continued)

Operational Task	**Observing** (Sensors/Platforms)	**Engaging** (Dynamic Engagement/ Execution Control)	**Killing** (Weapons/Platforms)
Suppress hostile artillery	• Imaging and GMTI radars on UAVs and satellites to track and locate enemy units • Ultra-wide band, very high frequency SAR on UAVs for foliage penetration • UGSs with acoustic sensors for target detection • Backtrack (fire finder) radar for artillery location • Reports from ground observers	• On-scene DEC from C^3I platform • Time-critical engagement (seconds to minutes)	• Air-delivered PGMs with unitary and dispenser warheads (geocoordinate and terminal guidance with <3mCEP) • Fast cruise missiles (same accuracy and warheads)
Defeat enemy air forces	• Tracking real-time deployment and location of enemy forces • Developing and tracking enemy triggering events for initiation of actions • Sensor location of critical elements of enemy air action at hase, marshaling, C^2	• Information provided within seconds to shooters through established filters to prevent information overload • Mission controller able to react within minutes to changing events in air battle • Decentralized execution at engagment level, given authority at mission level	• Disabling/destroying airfield/aircraft weapons on deployed bases - Mines - Runway and revetment destruction weapons - C^2 neutralizer • Offensive aircraft/UAV missiles with high single-shot probability of kill (> .9) • Countermeasure protection for platforms, avionics and weapons
Neutralize hostile space operations	• Monitoring, classifying and cataloging all satellites (nanoradians) • Monitoring all users • Knowing when satellites are operating in a hostile mode and what that mode is • Obtaining functional and/or physical BDA • Platforms: satellites, ground stations	• Thinking through "acts" and outcomes ahead of time • Preparing for very short time between triggering event and "action"	• Degrading power • Damaging/degrading/ denying imagery, navigation, and communication • Covertly upsetting attitude control • Platforms: touring satellites, DE weapons from surface, killer satellites launched on demand

Table 3 Key Elements of Operational Concepts (continued)

Operational Task	Observing (Sensors/Platforms)	Engaging (Dynamic Engagement/ Execution Control)	Killing (Weapons/Platforms)
Prohibit use of civilian facilities for military purposes	• Covertly monitor, classify, and catalog emissions and activities around and in suspected facilities • Observing pre-, during-, and post-attack conditions • Covert, invisible, UAV platforms and satellites; covertly implaced ground sensors	• Data fusion from all sources and assessment to support decisions on courses of action • Continuous supply of information essential for each element of forces engaged in task • Post-attack assessment from all sources to support quarantine lifting decision	• Precision general purpose and penetrator weapons • Long-range, high-speed, standoff weapons • Nonlethal antipersonnel weapons • Containment and minimum collateral damage • UAV, UTA, and aircraft weapon platforms; low observable weapon platforms
Achieve information dominance and situation awareness	• All-condition, high resolution imaging using very high resolution SAR and imaging EO on UAVs and satellites • ESM/SIGINT/emitter location on UAVs, C^3I aircraft and satellites • Specialized NBC detectors on UAVs and satellites • UGS with acoustic and chemical-biological detectors for traffic and WMD facilities	• Near real-time fusion assessment and display of combined signatures • Real-time threat warning • Overall surveillance management	• Cyber Techniques to impede enemy decisions and weapons employment • Physical destruction of C^4I weapons
Project power globally	• All condition high resolution imaging very high frequency SAR, IR, and imaging EO located on aircraft, UAVs, satellites and transatmospheric aerospace planes • ESM/SIGINT emitter sensor(s) on UAVs, aircraft, satellites, and remote ground sensors • Specialized NBC detector on UAVs and satellites • Real-time location and tracking of moving enemy forces by sensors located on satellites, remote ground sensors, UAVs, and aircraft	• Data fusion from all sources; assessment to define triggering events and targets • Centralized planning at commander level; decentralized execution at engagement level given authority at mission level • Very short time between triggering event and engagement action	• Precision general purpose munitions, clustered homing munitions, ARM homing weapons, penetrator weapons mines • Long-range, LO aircraft • CONUS-based global-range transatmospheric aerospace plane

Table 3 Key Elements of Operational Concepts (continued)

Operational Task	Observing (Sensors/Platforms)	Engaging (Dynamic Engagement/ Execution Control)	Killing (Weapons/Platforms)
Counter invading armies	• Satellite imagery EO/IR radar • Ultra-wide band, very high frequency SAR on UAVs for foliage penetration • EO/IR on UAV • Multisource, real-time theater intelligence system time histories, auto target recognition, image transmittal to shooters • Discriminating and killing defenses	• On-scene dynamic engagement control - C^3I platform - Deployable theater air war C^3I system • Direct real-time battlefield intelligence for all CONUS-based systems	• Electromagnetic warheads to disable critical sensors delivered by UAVs • Low observable attack aircraft with multimode attack sensors and auto target recognition • Advanced air-ground munitions with autonomous powered standoff
Rescue hostages	• Hostage location and tracking sensors on aircraft, UAVs, and satellites	• World-wide in progress real-time situation; awareness system	• Covert, world-wide rescue system, aircraft, SOF • Protection from interruption
Provide humanitarian relief	• World-wide disaster detection and monitoring system	• World-wide disaster command and control center • In country ground, space and air control	• All-weather, world-wide precision air drop • Aircraft self protection

4.0 What the Air Force Needs to Achieve these New Capabilities

4.1 Background

Our examination of the concepts described in the preceding chapter led to consideration of specific systems and technologies needed to accomplish the operational tasks. In this Chapter, we expand on the elements of an effective future force. These elements are grouped into several categories: sensors, platforms, weapons, countermeasures, command and control systems, logistics systems, and virtual systems for training and plans development. In each category, we first summarize the required functional capabilities and then suggest some candidate approaches intended to clarify our concepts and stimulate creative thinking about effective and affordable solutions.

4.2 Sensors

To support the operational tasks we have identified, U.S. forces require both capable sensors and sensor integration systems to process and fuse collected data on the locations and activities of potential threats and targets for offensive action. A model of the data-fusion process is needed to help select the functional elements and fusion processes that are matched to individual operational tasks. The new sensors must perform well in all conditions and operational situations. For example, they must be able to deal with vegetation and terrain masking, enemy CCD and other countermeasures, day/night and all weather, and heavy clutter such as in urban backgrounds. Also required are effective means to store, retrieve, and disseminate the large quantities of information produced by the posited sensors and processors.

Priority needs include the following:

- A continuous, all-condition, wide-area, high-resolution surveillance system with associated processing that classifies and builds time histories of targets of interest. Candidate sensor platforms are UAVs, a constellation of LIGHTSATS (light satellites), and UGSs. They will provide targeting information against air defense, TBM and cruise missile launch facilities, critical C^2 centers, NBC facilities, and other difficult targets.

- A comprehensive database of all relevant information to support situational awareness at all levels of the force structure. This database must be consistent and current and must provide multiple views to support specific user needs.

- Algorithms and processors for target detection, assessment, classification, and fusion. Processes such as automatic target recognition (ATR) must be flexibly applied to various situations and users. For example, ATR in a situational awareness sense typically involves refining the contents of files on targets in the area of interest, while in a time-critical engagement it may be part of a real-time decision process to verify that a triggering event has occurred.

- Sensors and associated processing to identify and track LO cruise missiles in clutter with supporting illumination to provide guidance for track and endgame kill.

- Ways to maximize the survivability of U.S. platforms by minimizing emissions. In one approach, a bistatic radar system with an illuminator in sanctuary (in-orbit, long-range air platform) coupled with receivers on multiple platforms would provide passive targeting.
- Sensors to support special operations. Specific needs include location, tracking, and communications with low probability of intercept in support of ingress and egress teams, along with specialized sensors for antiterrorist and hostage rescue operations.

Closely allied to sensing systems are reliable identification friend or foe (IFF) mechanisms to prevent fratricide. One candidate concept is the use of small, low-power, multispectral, low-probability-of-intercept (LPI) IFF beacons on friendly units to provide positive friendly identification of troops, vehicles, installations, and drop zones.

4.3 Platforms

The following illustrative concepts describe new platforms that can address the needs of the operational tasks in question.

Highly Survivable, Persisting, High-Altitude Endurance UAV for Theater Surveillance

For decades, the U-2, utilizing an evolving series of sensors and data links, has convincingly demonstrated the value of a high-altitude (70,000 feet and above), long-persistence platform. The Air Force needs a new platform (or family of platforms) that is highly survivable and has very long endurance to support multiple information-gathering and attack operations.

Among other operational uses, this platform would be a major element of future surveillance concepts to provide the air and ground coverage now achieved with platforms like AWACS and JSTARS, but over broader areas and with more capable, less expensive, and less vulnerable assets. Currently, the Defense Airborne Reconnaisance Office (DARO) is addressing this need with the Tier 2+ and Tier 3- programs.

The vista for a next-generation UAV system includes the following capabilities:

- Endurance: 20–40 hours
- Operating altitude: 80,000 ft or above
- Payload: 2,000–4,000 lbs
- Operating radius: 2,000–3,000 miles
- Onboard processing: Extensive target classification, data compression, etc.
- Speed: Subsonic
- Signature: Very low observable (all signatures) to persist over denied territory

Aircraft for Covert Operations of Special Operations Forces (SOF) and Others

We need to provide SOF and other covert operators with the capability to perform certain priority missions such as rapid, covert insertion and extraction of teams. Variants of the basic air

vehicle in this concept could be used for additional missions such as gunships and general purpose transports.

A new aircraft with the following capabilities would meet this need:

- Radius of action: 1,500 miles
- Speed: High subsonic
- Take-off and landing: STOL at base, VTOL and hover at destination
- Nominal payload: 3,000 lbs (10–15 people with equipment)
- Signature: Very low observable, including visual

Multipurpose Theater Support UAV

Flexible UAVs are necessary for a wide variety of theater support operations. Specific needs include long-term focused surveillance of areas of interest, mission flexibility through modular payloads that can be tailored to specific tasks, the ability to vary UAV signatures andemulate multiple targets in order to decoy and stimulate hostile air defenses, and the ability to deliver weapons such as those described in Section 4.4.

We posit a UAV or family of UAVs with the following capabilities:

- Radius of action: 500–1,000 miles
- Altitude: 100–40,000 ft
- Payload: Sensors or weapons weighing 750–1,500 lbs
- Special features: Very low observable, variable radar signature, variable infrared signature, unique LO visual signature—a "chameleon" UAV

Highly Survivable Attack Platform

The Air Force needs attack platforms that cannot successfully be attacked by any air defense system in the world. They must be capable of carrying large, flexible weapons loads and of flying missions without refueling. One such platform would take off, climb to altitude, and complete fueling for the entire mission before exiting friendly territory.

Postulated capabilities include the following:

- Radius of operation: 1,000 miles after fueling at altitude over base
- Payload: 10,000–15,000 lbs; up to 60 autonomous, very accurate, highly lethal munitions
- Signature: Very low observables in all signatures; major focus on low-frequency signature

Long-Range, High-Speed Aircraft for Global Strike and Reconnaissance

The Air Force needs the capability to rapidly perform surgical attack or very-high-resolution, multisensor reconnaissance directly from the continental United States (CONUS). Such an aircraft

would integrate multiple advanced technologies in structures, avionics, propulsion, observables, and other areas. A key enabling technology would be a new high-efficiency, high-supersonic engine.

We posit the following capabilities:

- Speed: Mach 3–3.5 or 5–6 (different engine technologies)
- Payload: 10,000 lbs
- Crew: 2
- Range: 3,000 miles if unrefueled, global if refueled
- Signature: Low observable (particularly radar)

Global-Range Transport Aircraft

The Air Force needs the capability to deliver certain types of cargo world wide, with precision airdrops, to meet national objectives in the area of humanitarian relief or combat operations. Such an aircraft would operate where airfields are not available or where hostile conditions preclude their use. This aircraft would be based on next-generation commercial aircraft technology. It might also be capable of launching UAVs.

Postulated capabilities include the following:

- Range: Global (9,000–12,000 miles)
- Speed: Subsonic at optimum cruise
- Payload: 150,000–250,000 lbs
- Crew: 3

4.4 Weapons

In general, weapons should combine the following characteristics for maximum effectiveness in various engagement concepts:

- Affordable
- All-weather
- Standoff
- Autonomous target engagement
- High-speed
- Near-zero CEP under all conditions
- High lethality with tailored effects
- Nonlethal
- Low collateral damage

The following is a summary of candidate weapon improvements and new concepts to provide the essential capabilities.

- Technological advances allow fielding of both air-to-air and air-to-ground weapons that deliver higher effectiveness in much smaller sizes than do weapons in the current inventory. Examples include more energetic explosives and propellants, novel kill mechanisms, smart submunitions and fuzing, and near-zero CEP guidance.
- Air-to-air missiles with greater effectiveness against LO air vehicles, even when in clutter. Also required is a long-range, air-to-air antiradiation missile (ARM) to counter high-value enemy surveillance/control and jamming platforms.
- Hypersonic interceptor missiles carried by high-altitude UAVs, UTAs, and manned fighters to destroy enemy ballistic missiles in the boost phase prior to thrust termination—a velocity of at least 5 km/second and a weight of 1,000 lbs or less are desirable goals.
- Hypersonic air-ground, long-range standoff weapons to attack high-priority, time-urgent, defended, and deeply buried targets. Current technology (non-LO) aircraft equipped with this weapon could attack targets deep inside enemy territory without crossing into denied airspace and exposing the aircraft to enemy air defenses. The weapon would cruise at Mach 6-8 at an altitude of approximately 100,000 ft.
- Speed-of-light weapons that can destroy/neutralize various enemy activities at operationally useful distances. These include both lethal, directed-energy weapons and various forms of standoff cyber weapons that attack enemy information systems. Goals include:
  - Neutralizing enemy radars before they can establish track
  - Destroying ballistic missiles before they terminate boost
  - Neutralizing enemy integrated air defense system (IADS) networks
  - Bringing down enemy communications networks
  - Destroying the control functions of an incoming missile before it gets close to our aircraft
- Weapons to temporarily incapacitate personnel, particularly for use in situations involving human shields and innocent bystanders.
- Means of neutralizing NBC sites while containing the release and dissemination of hazardous materials. This may include weapons to attack deeply buried, extremely hard, and concealed or shielded targets.
- A covert (and/or plausible denial) means of selectively damaging/degrading enemy or co-opted commercial satellites permanently or temporarily.

4.5 Countermeasures

Increasing sophistication, lethality, and proliferation of weapon systems among potential adversaries has increased the need for countermeasure protection against enemy-attack systems as well as for protection of U.S. offensive systems. Candidate approaches to this problem include:

- Countermeasure protection against IR and radio frequency (RF) guided missiles, both air and ground launched, is a high-priority need. Improvements are possible through development and deployment of advanced radar and imaging IR guided missile countermeasures. Lasers, decoys, flares, and HPM weapons have varying levels of capability, and a coordinated program employing an optimized combination of methods could take a major step toward satisfying the need for protection of air platforms. The RF missile challenge requires concentration on techniques for countermeasures to complement efforts on digital receiver/processors for situation awareness. The IR missile challenge is to develop countermeasures effective against focal plane array IR seekers.

- Offensive counter-countermeasures for U.S. avionics systems are also a priority need. To stay ahead of threats, radars, warning systems, missiles, smart munitions, and other systems we need innovative ways to apply advanced algorithms and processing, integrated functioning, and improvements in sensitivity, bandwidth and discrimination.

4.6 Command and Control Systems

A robust, deployable theater command, control, and communications system, capable of supporting rapid planning and real-time execution control of a complex theater war, is central to many critical operational tasks. This system will include the ability to provide near-real-time data on the status of the battlefield down to individual vehicles. It will include the capability to conduct realistic simulated theater war campaigns and mission rehearsals. It will utilize commercial technology—architecture and standards, computers and peripheral equipment, programming languages, and system software. It will be capable of conducting a theater air war from the theater or, when necessary, from CONUS. There is also an urgent need for theater doctrine and concepts of operations to employ mixed forces with manned aircraft and UAVs, as well as C^3 systems to assure safe and reliable operations of this mixed force. (Dynamic Planning and Execution Control was discussed in detail in Section 3.2.)

4.7 Logistics Systems

The technology exists or can be developed to revolutionize Air Force logistics support capability. Achieving a 50 percent cost reduction in ten years is a realistic objective. By 2020, logistics costs should be no greater than 20 percent of today's costs. Areas with opportunities for major improvements include the following:

- Develop and implement concepts for beginning operations quickly and sustaining operations at high intensity—especially at remote locations—by having all support functions become self-contained, with munitions and fuel being the only exceptions.

- Reduce the cost of ownership and improve the availability of weapon systems. One powerful approach would be to design all new systems against a firm requirement that there would be no unscheduled maintenance other than repair of damage from mishaps and battle. This would provide the basis for one-and-a-half level maintenance, i.e., base and periodic depot maintenance.
- Because aircraft are retained in the inventory for very long lifetimes, ensure structural integrity and affordable detection and correction problems. Technology will allow the development of portable, computationally powerful, nondestructive inspection (NDI) field instruments for early detection of structural problems (corrosion, cracking, delamination, wiring faults, etc.)
- Similarly improve the intrinsic durability of U.S. systems against fatigue and corrosion and achieve self-diagnosis of structural health. This requires development of new materials and treatments (probably nonmetallic), smart structures, and embedded integrity sensors that eliminate corrosion, cracking, fatigue, etc., over 30-year air vehicle operating lifetimes.
- Reduce the costs of weapon system software maintenance. Design and implement operational flight programs and support system software, including automatic test software, that can be modified and updated without writing code–i.e., use commercial software best practices.
- Reduce costs associated with the procurement, store, stock and issue functions of supply. The technology is available to rapidly implement completely automated materiel handling, inspection and shipment systems to provide fast logistics support worldwide with minimum inventory, minimum response time, and minimum manpower. This could be linked to a replenishment procurement system that uses artificial intelligence to continuously assess inventory and consumption to maintain required stockage at minimum cost. The Air Force should also include provisions to track every item and person in the transportation pipeline and all materiel in storage at every location worldwide—and do this at least as well as UPS and FedEx do today.

4.8 Virtual Systems for Training and Plans Development

Today's global environment imposes new and important demands that directly involve high-level decision makers, both civilian and military. The evolving, chaotic situation in Bosnia clearly demonstrates both a current and lasting requirement for very rapid information distribution of critical data to tactical users, as well as the absolute necessity for rapid decision making. Accordingly, the following actions are necessary:

- Create facilities that expose all levels of command, both civilian and military, to realistic situations in a high-fidelity, intense, and real-time environment. Use these facilities to educate and prepare decision makers and to practice and refine decision processes. Achieving the full potential of concepts from *New World Vistas* will depend critically on the right decisions at the right time at all levels of command.

- Provide training facilities at the tactical level that simulate the intense interaction of sensors, assessors, controllers, shooters, and evaluators in dynamic engagement control. These are required to evaluate concepts and to train the appropriate personnel in an intense and interactive environment.
- Formulate explicit doctrine and a framework for thinking about modernizing the Air Force to meet future needs, focusing intensely and continuously on "concept developments." Developing *New World Vistas* is a never-ending task.

5.0 Potential Revolutionary Concepts

5.1 A History of Scientific Achievement

The existence and historical progress of the Air Force is remarkable for the aggressive exploitation and fielding of revolutionary technologies: the Wright Flyer, the variable pitch propeller, lightweight aluminum alloy aerostructures, the jet engine, the atomic bomb, very-high-thrust liquid rocket engines, high-performance solid rocket engines, satellites, airborne radar, airborne analog computers, airborne digital computers, inertial navigators, stealth aircraft, and many others. The list is very long and must continue to grow. We suggest seven potentially revolutionary concepts.

5.2 "Invisible Air Vehicle"

Either a manned attack aircraft or UAV for reconnaissance and/or strike, this vehicle would have an extremely low radar cross section over a very wide frequency range, an extremely low spectrally and spatially tailored infrared signature, a very low visual signature, essentially no electromagnetic emissions, a very low acoustic signature, and only passive sensors. It would integrate all elements of the most advanced low observable technologies to provide a vehicle having very unique and *stunning* operational capability, a critical element of the air dominance sought by the United States.

5.3 Speed-of-Light Weapons

Our *New World Vista* includes operational use of directed-energy weapons, which will range from relatively low-power electromagnetic weapons to extremely high-power lasers capable of destroying or disabling targets at ranges of 400 km or greater. Such weapons are very fast (from 1/1000 to 15/1000 of a second), reusable, and extremely accurate. They would perform operational tasks, such as killing theater ballistic missiles, that cannot be performed today.

5.4 Radio Frequency Warhead-Disabling Enemy RF Sensors

Unique advanced technology would be used to store a large amount of electrical energy in a very small volume. The weapon would generate a very-high-power electromagnetic pulse capable of disabling enemy radars, communications, and computer systems. Since its effective radius would be limited, it might be employed at close range by a tactical UAV. It would be most immediately useful upon the initiation of hostilities. It would also be useful and effective in stopping hostilities among warring factions, where temporary disablement of radars has major value.

5.5 Small, Precise, Tailored - Effects, Air-to-Ground Weapons

All of the concepts involving strike or ground attack using other than DE weapons, demand a capability to deliver maximum firepower per attack asset per unit time. This must be accomplished precisely and in day/night/all weather conditions and by weapons that greatly increase the kill potential per sortie. These smaller weapons properly targeted will significantly increase the number of targets attacked per sortie. In addition, the "tailored effects" capability enables a single munition to be effective against more than one target type, thus simplifying planning and logistics.

5.6 Bistatic Radar System for Battlefield Use

A bistatic radar system would have an illuminator in sanctuary, either in orbit or on a long-range aircraft. Receivers would be in multiple platforms over enemy territory, thus enabling passive sensing by these platforms for many functions, including econnaissance, surveillance, targeting, and weapons launch. In cases where the strategy of potential enemies depends on exploiting radar transmissions, such an aircraft would provide revolutionary capabilities.

5.7 Light-Weight, Affordable, Launch-on-Demand Surveillance Satellites

The ability to rapidly orbit a tailored constellation of satellites with multimode radar and other sensors, powerful onboard processing, and robust data links supports many operational concepts. Advanced vehicle and sensor technologies make feasible a class of satellites with a lifetime on the order of one year. These satellites would provide substantial all-weather imaging and moving target indication/GMTI capability at high revisit rates (less than 10 minutes) and with the survivability and assured access inherent in orbital platforms.

5.8 Next Generation C^3I Systems and Platforms

Replacement of C^3I systems and platforms on a one-for-one basis is not practical. However, similar functions to those provided by these aircraft could be accomplished via a distributed, netted set of survivable UAVs and/or satellites (see above). The data/information they collect would be sent to survivable, relatively remote ground stations or manned air vehicles for assessment and control functions in real-time. The sensor platforms would be more survivable than current platforms are. They would also be able to support other surveillance missions when not providing data for air- or ground-controlled intercepts. Alternatively, the next generation of C^3I systems could be combined and fielded in a derivative of a single large commercial aircraft.

5.9 Global-Range Transatmospheric Aerospace Vehicle

The global-range transatmospheric aerospace plane would be housed at existing Air Force bases within CONUS. It would be used to perform on-demand reconnaissance and strike missions anywhere in the world. It would be capable of overflying any location in the world in less than two hours and returning to CONUS in less then three hours from time of take-off.

The aerospace plane would require airplane-like ground operations and could be maintained within the current aircraft infrastructure. A Mach 18+ boost-glide-skip flight path would enable a global-range capability. (Mach 18+ for unrefueled global range capability is much less difficult and costly than the Mach 26 needed to achieve orbit.) The plane would provide very rapid reconnaissance when finer detail of a specific area is required to finalize preparations for or initiate action against a specific objective.

In the transatmospheric phase of flight, the vehicle could deploy weapons that could strike a critical target very precisely. This would give the United States an ability to *swiftly* attack terrorists in their homeland and destroy critical facilities associated with WMD (manufacturing in particular) with impunity.

The aerospace plane is the first stage of a two-stage space-launch vehicle. The second stage used to deploy the satellite into operational orbit could be reusable, or it could be a propulsion module (like those used in the planetary program), which is different from an upper stage or an orbital transfer vehicle in that the guidance and control function is performed by the satellite. Propellant tanks and engines are the principal components of a propulsion module.

6.0 Overarching Recommendations

6.1 The Air Force will Need Major New Capabilities to Dominate Future Theater Air Operations

Clearly the potential exists for the Air Force to gain a dramatic improvement in its capability to meet any theater air requirements of the future in a rapid and convincing manner. However, this will not be easy, technically or financially. Most future theater wars are likely to involve an enemy who will employ surface-to-surface missiles, both ballistic and cruise. The Air Force must be able to defeat these and many other difficult threats, including a wide variety of surface-to-air missiles.

6.2 The Air Force must Define Its Vision and State Its Required New Capabilities

We believe that Air Force needs to produce a concept of operations for theater air operations in the 2020–2030 era. This vision would be extremely valuable in focusing and prioritizing advanced technology and advanced system development, both within the Air Force and throughout the defense industry. Our nation is caught up in an era of rapid, dramatic change; and a beacon is needed to guide it down the right path.

6.3 Carefully Exploit Information Technology to Improve Warfighting Capability

The commercial information technology revolution will continue unabated, independent of any Air Force initiatives. The Air Force must define system architectures which exploit this technology operationally, based on the Doctrine of Dynamic Planning and Execution Control, including force management, mission control, and engagement control.

6.4 Develop and Field a New Family of Multispectral Sensors

Far more capable sensors are technically feasible and of great operational leverage in aircraft, UAVs, and weapons. They will have sufficient resolution and accuracy to permit automatic target recognition and near-perfect weapons accuracy. To be affordable, they must be made modular and standardized and must make maximum use of commercially developed technologies.

6.5 Aggressively Develop and Exploit Infrared Technology, Both Offensively and Defensively

For over 50 years, the Air Force has been crucially dependent on radar. However, in the early 21st century, the Air Force will be increasingly challenged by advanced infrared-based systems and technology, including infrared missile threats. The Air Force must give infrared technology and systems development intense emphasis in several areas: infrared signatures of vehicles; infrared sensors for a range of applications, including infrared missiles; and infrared countermeasures, particularly against missiles having focal plane array seekers.

6.6 Continue to be Dominant in Fielding Low Observable Technology-Stealth

Stealth continues to advance rapidly, not only in a technical sense but also in terms of affordability. The Air Force should continue to be the world leader in fielding stealth systems, as it has been in the past. One way for the Air Force to defeat the inevitable counter-stealth initiatives is to continue to field more stealthy systems for which no potential adversary can afford a counter-stealth-based defensive system. (See Appendix F.)

6.7 Field UAVs to Gain Major New Warfighting Capabilities

In our *New World Vista*, UAVs will emerge to provide dramatic new capabilities, primarily real-time battlefield intelligence not available from other systems. The Air Force must develop operational concepts and operational priorities to exploit UAV technology. A long-endurance, highly survivable UAV for real-time battle surveillance has the greatest operational value.

6.8 Exploit Advanced Technology to Field Far More Effective Conventional Weapons

A family of advanced technologies is emerging that will allow the development of more accurate, smaller, and more affordable weapons with tailored effects, both lethal and nonlethal. Effectiveness per pound will be doubled or tripled.

6.9 Field Revolutionary Systems

- An "invisible air vehicle"
- Speed-of-light weapons
- An electo-magnetic weapon for disabling enemy RF sensors
- Small, precise, tailored-effects air-to-ground weapons
- A bistatic radar system for battlefield use
- Light-weight, affordable, launch-on-demand surveillance satellites
- Next-generation systems to replace C^3I systems and platforms
- A global-range transatmospheric aerospace vehicle for strike and reconnaissance

6.10 Conclusion

The tasks specified in this report are familiar and enduring. The U.S. military must now search for innovative, even revolutionary, ways of accomplishing them. The nation will then possess the capability to *dominate* the activities of *all* types of enemy forces—land, naval, air, or space. And being able to deter, prevent, or neutralize enemy operations and to operate at will, the U.S. Armed Forces can conduct any mission, dominate any battlefield, win any war, and thus carry out their common mission to achieve the national security objectives of the future:

- Protect interests vital to the security of the United States, especially from major regional aggressors

- Counter weapons of mass destruction
- Control regional instabilities. Cause and enforce a cessation of military operations among warring and recalcitrant factions
- Promote world order. Establish and maintain a peace among wary and distrustful nations
- Accomplish special missions at the direction of the President and the Secretary of Defense
- Advance the nation's enduring values and interests: promote democracy and provide relief and hope

Appendix A

Attack Panel Charter

The charter of the *New World Vistas* Attack Panel is to define the types of operational capabilities the United States Armed Forces—in particular the United States Air Force—should possess to move toward the ultimate goal of being able to conduct any mission, meet any contingency, dominate any battlefield, and win any war.

The panel will accomplish this by:

- Describing enduring operational tasks in terms of objectives, triggering events, detecting and locating events, special circumstances, and capabilities needed to underwrite the concepts
- Defining "must have" functional capabilities, i.e., without which the concept cannot be realized
- Prioritizing concept-development activities
- Defining revolutionary concepts

The panel's output will serve as one integrating device in which to place the findings of the other *New World Vistas* applications and technologies panels.

Appendix B

Panel Members and Affiliations

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Appendix C

Panel Meeting Locations and Topics

3-5 May 1995 Maxwell AFB, AL

Tasks, Operational objectives, Attack process, Hostage rescue, Aerospace power operating in air and space, Air occupation versus land occupation

25-26 May 1995 Washington, DC

Panel objectives, DARO UAV concepts, Refinement of task list, Identification of required sensor, platform, weapons, and engagement control functions

21-22 June 1995 Washington, DC

Development of a standard format for addressing and presenting operational objectives and tasks relevant to other *New World Vistas* panels, Unmanned tactical aircraft, Hypersonic global aircraft

7-8 July 1995 Newport Beach, CA

Outline of final report, "Key Concepts" list

10 October 1995 Santa Monica, CA

Review of final report

Appendix D

List of Acronyms

Acronym	Definition
AAA	Antiaircraft Artillery
AAM	Air-to-Air Missile
ABL	Airborne Laser
AI	Artificial Intelligence
AJ	Antijamming
AOA	Angle of Arrival
APC	Armored Personnel Carrier
ARM	Antiradar/Radiation Missile
ATE TPS	Automated Test Equipment Test Program Set
ATM	Asynchronous Transmission Mode
AWACS	Airborne Warning and Control System
BAT	Brilliant Anti-Tank (Weapon)
BDA	Battle Damage Assessment
BVRID	Beyond-Visual-Range Identification
CAS	Close Air Support
C^2	Command and Control
C^3	Command, Control, and Communications
C^3I	Command, Control, Communications, and Intelligence
C^4I	Command, Control, Communications, Computing, and Intelligence
CCD	Camouflage, Concealment, and Deception
CEI	Critical Elements of Information
CELM	Counter Enemy Launched Missiles
CEP	Circular Error Probability
CINC	Commander in Chief
CM	Countermeasure
CNN	Cable News Network

CONUS	Continental United States
DARO	Defense Airborne Reconnaissance Office
DPEC	Dynamic Planning and Execution Control
DPECIS	Dynamic Planning and Execution Control Information System
DE	Directed Energy
DEC	Dynamic Engagement/Execution Control
DIS	Distributed Information System
ECCM	Electronic Counter-Countermeasure
ELINT	Electronic Intelligence
EMD	Engineering Manufacturing Development
EO	Electro-Optical
ESM	Electronic Support Measures
FOPEN	Foliage Penetrating (Radar)
GBU	Guided Bomb Unit
GMTI	Ground Moving Target Indication
GPS	Global Positioning System
HARM	High-Speed Antiradiation Missile
HE	High Explosive
HPM	High Power Microwave
HUMINT	Human Intelligence
IAD	Integrated Air Defense (System)
ID	Identification
IFF	Identification Friend or Foe
IGPS	Inertial Global Positioning System
IR	Infrared
I&W	Indications and Warning
IRCM	Infrared Countermeasure
JAST	Joint Advanced Strike Technology
JCS	Joint Chiefs of Staff
JDAM	Joint Direct-Attack Munition
JFC	Joint Forces Commander

JSOW	Joint Standoff Weapon
JSTARS	Joint Surveillance and Target Attack Radar System
kts	Nautical Miles per Hour (knots)
LAN	Local Area Net
LGB	Laser-Guided Bomb
LIGHTSATS	Light Satellites
LOCAAS	Low-Cost Autonomous Attack System[4]
MS&A	Modeling, Simulation, and Analysis
MTI	Moving Target Indication/Indicator
NASP	National Aerospace Plane
NBC	Nuclear, Biological, and Chemical
NCA	National Command Authorities
NCTR	Noncooperative Target Recognition
NDI	Nondestructive InspectionNondevelopmental Items
nm	Nautical Mile(s)
NTB	National Test Bed
NSC	National Security Council
OFP	Operational Flight Program
OODA	Observation, Orientation, Decision, and Action
Ops	Operations
PGM	Precision-Guided Munition
P^3I	Preplanned Product Improvement
P_k	Probability of Kill
POL	Petroleum, oil, and lubricants
RCS	Radar Cross Section
RF	Radio Frequency
Recce	Reconnaissance
RV	Reentry Vehicle
ROE	Rules of Engagement

4. LOCAAS was previously known as Low-Cost Antiarmor System

SAM	Surface-to-Air Missile
SAR	Synthetic Aperture Radar
SATCOM	Satellite Communications
SEAD	Suppression of Enemy Air Defenses
SFW	Sensor-Fuzed Weapon
SIGINT	Signals Intelligence
SOF	Special Operations Forces
SWC	Space Warfare Center
STOL	Short Take-Off and Landing
TACCSF	Tactical Air Command and Control Simulation Facility
TBM	Theater Ballistic Missile
TELs	Transporter Erector Launchers
TDOA	Time Difference of Arrival
UAV	Unmanned Air Vehicle
UGS	Unattended Ground Sensor
UTA	Unmanned Tactical Aircraft
UWB	Ultra-Wide Band
VHR	Very High Resolution
VTOL	Vertical Takeoff and Landing
WSC	Weapon System Concepts
WMD	Weapons of Mass Destruction

Appendix E

This appendix contains detailed descriptions of the operational tasks discussed in Section 3.0. The concepts are described in the order shown below:

E.1 Establish Dynamic Planning and Execution Control

E.1.1 Achieve Information Dominance

Statement of the Operational Task. The U.S. military must achieve information dominance. That is, it must always know the plans and activities of the enemy in time to respond, and it must deny the inverse.

Introduction. The battle commander with near-perfect knowledge of the battlespace has an immense advantage in applying his own forces to gain his objectives while neutralizing those of his opponent. Conversely, to the extent that the commander can deny equivalent knowledge to his adversary, he achieves the same dominance. The challenge is in many ways exacerbated by growing threats of terrorism, proliferation of nuclear, biological, and chemical (NBC) weapons, and the growing threat of extremely difficult targets such as mobile theater ballistic missiles. The following discussion offers a concept for achieving the greatest possible level of information dominance across the spectrum of levels of conflict.

Specific Objectives :

- Have the assured ability to collect information anywhere on the globe, under all conditions, and with selective continuous observation of areas and locations of interest.

- Be able to detect, locate, track, and classify all things of military significance in a designated area of interest, including mobile targets; buried facilities; and targets protected by camouflage, concealment, and deception (CCD), including NBC targets.
- Be able to gather, assess, and disseminate information on timelines that support decisions at all levels of the force structure.
- Possess information-gathering mechanisms that are survivable and functionally robust in the face of hostile action and countermeasures.

Challenges:

- Threats posed by terrorists, NBC weapon manufacturing and stockpiling, buried and hardened structures for key facilities, and use of civilian activities to mask military activities all present extremely difficult sensing and evaluation problems.
- Threats such as TBMs and air defenses demand effective responses in seconds to minutes, only a fraction of which time is available for information gathering and transmission.
- Detailed, accurate information is likely to be required simultaneously on multiple areas scattered about the globe. The ability to rapidly detect hostile actions or preparations whose locations are initially unknown within vast areas will be especially important.

Triggering Event. This task will be invoked in response to a determination that a given nation or group has the capability and intent to threaten the national interests of the US. Surveillance of known or suspected hostile nations and groups can be expected to be more or less continuous, regardless of the official level of hostilities. However, the primary focus of this operational concept, which is to deliver information dominance to a commander engaged in a defined confrontation, will be triggered by the event which generates the confrontation. This can be anything from a terrorist threat to a preemptive ballistic missile strike. Information that substantiates the occurrence of a triggering event is similarly varied and could range from an intelligence assessment to the detection of a hostile act such as a missile launch through our normal, on-going global surveillance. Whether the conflict involves a SOF team or an all-Service theater combat force, the appropriate level of command authority must receive credible and accurate information on the triggering event and issue the necessary directives. Those directives must include the establishment and tasking of information-gathering and information-security measures aimed at achieving information dominance and thus successful prosecution of the engagement. The associated decision timelines may vary from a few minutes to deal with a missile launch to days or weeks to deploy a large combat force, but the information processes must always operate within the timeline that applies to a specific situation.

Assumptions. All information collection and analysis assets with access and capability in the area of interest will be employed. This task will support the CINC, the Joint Forces Commander (JFC), or other command authority charged with dealing with the enemy, and it will respond to the information needs of that command authority.

Summary Description of the Operational Concept. (See Figure 6.) Sensors and other intelligence collectors, data processing, communications networks, and automated and manual analysis and assessment will be employed in an integrated framework to develop a comprehensive, near-real-time picture of the enemy's force dispositions, movements, force support, and other pertinent activities. This information will be fused, assessed, and presented to command authorities at all levels of the force structure as appropriate to support planning, decision making, and operations. Trends and patterns in enemy activity will be analyzed in light of historical and intelligence data to evaluate enemy plans and intentions.

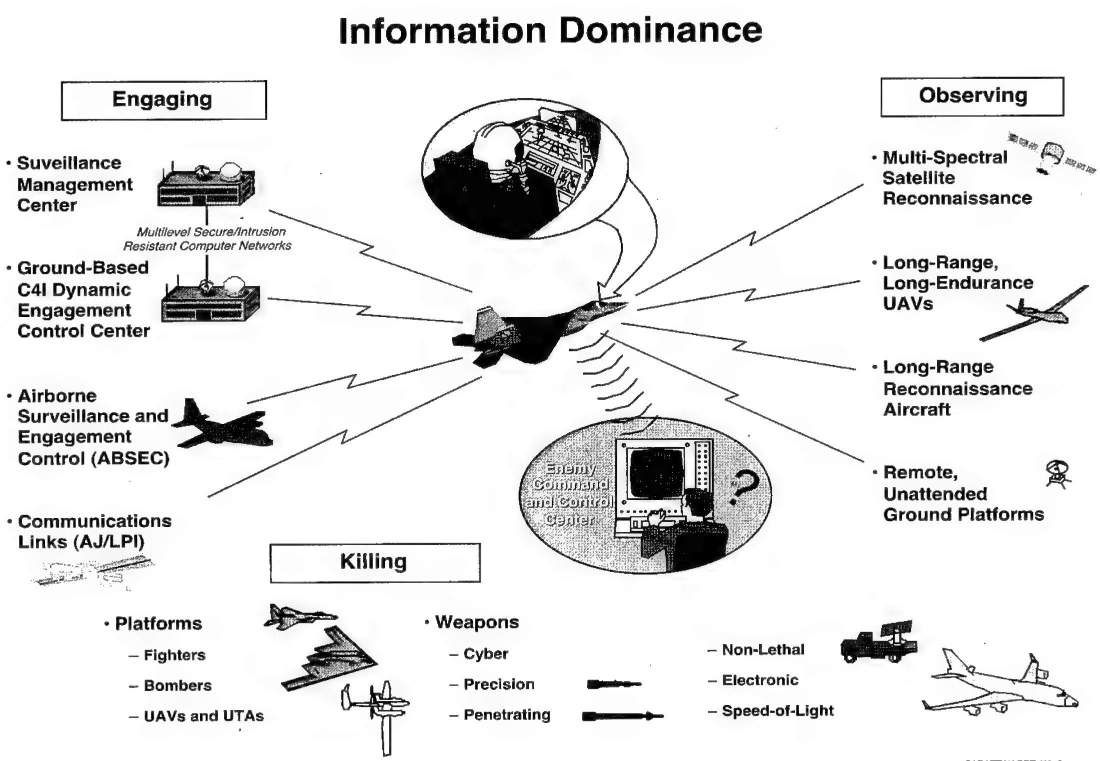

Figure 6

Elements of the Concept:

- Sensors and Intelligence Collectors
  - For ground targets, imaging sensors, including SAR radar for all weather coverage and EO sensors for selective high-resolution imagery, will be used to locate and identify forces, equipment, facilities, routes of movement, etc. Resolution of 1 ft or better is required for high-confidence target classification. Combined sensor assets will provide continual surveillance of the entire area

of interest and continuous surveillance of selected areas of special interest. Change detection in time-phased imagery will be used for moving-target detection. Time histories from imagery will be used to locate and evaluate facilities, force dispositions, and activity patterns. Special techniques such as ultra-wide band (UWB) SAR will be used to detect targets in foliage, camouflage, shelters, or underground locations.

- GMTI radar modes will be used to detect moving ground targets. Time histories will be used to determine routes of movement and activity patterns. GMTI radars will be able to discriminate targets down to a minimum velocity of 2.5 knots. GMTI will be used to cue and focus imaging and other sensors.
- Three-dimensional tracking radars will be used to detect and track aircraft, UAVs, cruise missiles, and any other aerial targets. Combined sensor assets will provide continual surveillance of the entire area of interest and continuous surveillance of selected areas of special interest. Time histories will be used to support noncooperative target recognition (NCTR), chiefly through track-from-origin, and to establish patterns of activity. Special techniques will be used to detect LO targets.
- Spectrum-surveillance and signals-interception (including wire taps or equivalent) sensors will be used to capture enemy message traffic, including voice and data. Coverage will include known or probable activity sites. Time histories will be used to assess activity patterns and to build a basis for identifying individual message types or senders.
- Radar and EO sensors will be used to detect enemy satellites, accurately determine their orbits, and classify their characteristics and functions. Time histories of imagery and intercepted up/down link traffic will be used to assess functions and detect changes.
- Information from human agents, prisoner interrogations, open-source intelligence collection and any other sources of interest will be gathered and integrated with sensor information to support the requirements of this task.
- Appropriate sensors will be used to detect and locate chemical, biological and nuclear weapons, materials, production facilities, movements, and storage sites. Special sensors will interact with conventional imaging and GMTI sensors to improve the quality of NBC detection. Coverage will include known and probable sites and routes for NBC activity. Time histories will be used to determine patterns of NBC activity and detect changes.
- Seismic, acoustic, and possibly other sensors will be used to detect ground traffic, measure aircraft ground movements, detect explosions, monitor events in shelters or underground facilities, etc.

• Assessors and Disseminators

  - All collected data will be screened for relevance and context; extraneous data will be discarded; and related data streams (e.g., multiple sensor signatures of

a given target) will be fused and stored as single database entries. Maximum feasible use of automated pattern recognition, statistical estimation, and other processing techniques will be used to increase the speed and efficiency of the analysis-and- assessment process and to minimize required manual intervention. These processes will be distributed as appropriate to sensor platforms and other nodes of the C^4I network to minimize required data transfer rates and maximize overall throughput and responsiveness.

- Automated and, as required, manual processes will be used to assess information derived from information collectors and processed as above. Individual targets (vehicles, facilities, troop formations, etc.) will be identified or classified. Patterns (e.g., troop dispositions, aircraft dispersals, training tempos, etc.) will be similarly identified and assessed. Spatial and temporal data will be stored and marked in a common coordinate system. Indications and warnings analysis will be used to detect threatened or potential hostile action. Overall assessments will be performed as directed by command authorities and supported as appropriate by correlation with historical or other data, including estimates of hostile plans and intentions.

- Information and assessments will be promptly disseminated to locations and personnel having a need for them, using communications channels which are robust in the face of failures and hostile action and secure against interception. Access privileges will be determined by command authorities. A mixture of "push" and "demand" transactions will be used in accordance with priorities and procedures established by command authorities.

• Controllers

Information and assessments will be presented through displays, annunciators, briefings, and other means as appropriate to meet the needs of commander, weapon controllers, and other decision makers at all levels of the force structure. Reporting means will make maximum use of ergonomic design to support effective interaction between information sources and their users. Content and timing of reports will support decision timelines.

• Platforms and Weapons

- Satellites, UAVs, UTAs, manned aircraft, and ground-emplaced platforms may be used for electronic surveillance and signal interception. Satellites, UAVs, UTAs, and unattended ground-sensor (UGS) platforms may be used for NBC sensors. Seismic and acoustic sensors may be airdropped or hand emplaced and will in general be UGS designs. Ground stations will be used for space-object sensors. Human agents may operate in hostile territory and in other intelligence contexts.

- Information collection platforms will function as an integrated structure to deliver maximum support to command authorities. Overall priorities and operating modes, as well as tasking of individual sensors, will be based on flexible, robust, and timely decision support. Examples include cueing of point

sensors by area sensors, dwell schedules for staring sensors, and streamlined reporting channels for high-priority information. In addition, the assets and personnel performing this task will be coordinated with other elements of the force structure, especially with combat forces, to maximize their effectiveness and survivability.

- A wide range of offensive and defensive information techniques will be employed. Offensive measures may include disruption of enemy information processes, injection of disinformation, physical destruction of sensors and other information assets, and any other steps which may interfere with his timely collection and use of information. Conversely, defensive measures will be implemented to prevent the enemy from accessing or corrupting our information processes; for example, data communications will be secure; LPI, and jam-resistant and computer networks will protected against injection of malignant code (e.g., viruses) or disinformation.

Capabilities and Technologies We Need

- Platforms that can persist over enemy territory. For example, a highly survivable UAV equipped with a rich inventory of modular payloads that allow tailored capability for all types of information collection missions.
- Sensors that can detect, locate, and classify NBC materials, weapons, storage sites, and manufacturing facilities. For example, an internetted array of UGSs (including the means to covertly emplace them) able to detect effluents and classify materials and agents, plus the data transmission infrastructure to collect sensor outputs.
- Sensors that can rapidly and accurately locate and classify air defenses, including acquisition and tracking radars, SAMs, and AAA, to allow effective SEAD at the outset of hostilities.
- Sensors that can observe large areas in heavy clutter under all conditions of lighting and weather and can extract accurate information on large numbers of fixed and moving targets. For example, ultra-high resolution (UHR) SAR that can be carried on affordable air platforms and can deliver imagery of sufficient quality to identify armor, TELs, military installations, and other targets at very high frame rates to allow near-simultaneous surveillance of large areas.
- An information architecture in which sensors, automatic and manual assessment, communications, and decision making are internetted and function optimally to deliver maximum information dominance. This includes distribution of data processing and assessment and high levels of autonomy of individual assets within the network to save time and reduce data transmission by discarding irrelevant data and compressing the rest.
- Communications for voice, data, imagery, and all other traffic that are highly secure, low latency, antijam (AJ), and low probability of intercept (LPI).

- Computers, networks, data storage, and other information processing assets that are immune to hostile penetration.
- Methods to assure "truth maintenance" (synchronization and consistency) in large, distributed databases.

E.2 Counter Weapons of Mass Destruction

E.2.1 Theater Ballistic Missile Defense

Statement of the Operational Task. Ballistic missiles launched from a designated territory will be destroyed/neutralized prior to the termination of boost or prior to fractionation.

Introduction. The United States must be assured no enemy can employ weapons of mass destruction against our troops and allies. These weapons can be delivered by various platforms: cruise missiles, theater ballistic missiles, commercial vehicles, etc. This discussion addresses ways of countering delivery by theater ballistic missiles.

Triggering Event. At the tactical level, the triggering event for this task occurs when the enemy launches a ballistic missile. Prior to that time, there has been a triggering event at the strategic level—for example, the rogue government has massed armored units on the border of our ally. This prompts the United States to respond in force. At this stage, the objective is to keep all enemy missiles from getting on their launchers or, if they do, to kill them on the launchers. Our first action is to attack all suspected NBC sites and then put a "cap" over the entire area so that there can be no movements from any facilities. However, in the context of an in-depth defense, the U.S. military must have the capability to neutralize any missiles that may be launched and do so before they terminate boost.

Assumptions

- Prior efforts will generally prevent launches of these missiles.
- The rules of engagement are straightforward. Other triggering events have prompted the United States to respond in force. Part of responding in force is to put a "cap" over the territory of the rogue government so that no missiles (ballistic in this case) can exit the country. If any ballistic missiles are actually launched, we will engage them quickly to the best of our ability to do so, and quite automatically through centralized command decisions and completely decentralized engagement/execution control.

Summary Description of the Operational Concept

- The concept is to "put a lid" over a designated area or areas (Figure 7). The lid may consist of the following platforms: ABLs on 747s operating over friendly territories, extremely fast interceptors on naval ships in adjacent waters, and UAVs at high altitudes over enemy territories. The UAVs must cover those areas that the ABLs and naval ships cannot. This discussion addresses only one of these platforms: UAVs over enemy territories.

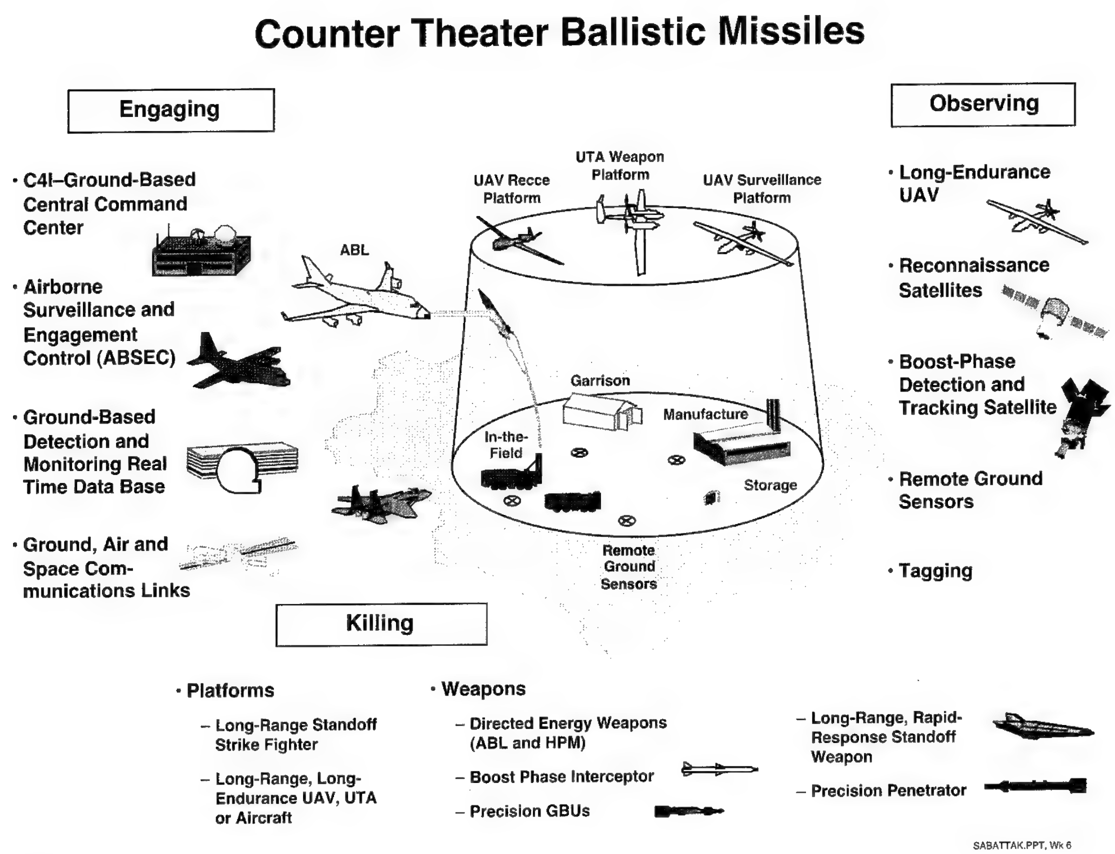

Figure 7

- We will use any sensor (or combination of sensors) that reliably and quickly provides information about the triggering event, the launch of the enemy missile. We will equip our CELM (Counter Enemy Launch Missiles) with MTI radar and reliable IR sensors. We will also employ other (off-board) sensors if available and useful.
- After the triggering event, response time is very short. We must destroy the missile prior to termination of boost. With the right sensor and control functions, we should be in a position to attack within seven seconds after launch, perhaps less. The rules of engagement are "guns at the ready." The problem is to kill the target in a short time, i.e., in seconds. Speed-of-light weapons—e.g., lasers and HPM weapons—have sufficient speed to get to the target quickly but may be lacking in energy at long distances. Conversely, missiles with HE warheads have the energy to destroy the target once they arrive, but they have difficulty reaching the target because of the engagement dynamics.
- For a missile (our interceptor) rated at 4 km/sec, for the case of a 57-second TBM burn time, the footprint of our CELM UAV is limited to approximately 200 km. It may be necessary to settle for such a weapon, but we will then be at the mercy of

burn times. If the burn time is halved, the footprint and the number of UAVs required is quadrupled.

- Speed-of-light weapons solve the "burn-time" problem. These weapons are of two types: (1) those that depend on depositing a large amount of energy in a short time to cause physical damage to components, circuits, etc., (high-energy lasers and HPMs are examples) and (2) weapons that operate on the nervous system of the enemy system—so-called "cyber weapons". We are interested in both types as long as they have the appropriate ranges of lethality, which begin at 100 km. The 100 km requirement is based on the fact that, with an interceptor rated at 5 km/sec, a footprint of 100 km can be obtained even in the presence of TBM burn times as low as 27 seconds.

Elements of the Concept

The panel formulated a concept centering on use of UAVs over enemy territory to fill in the "gaps" that other platforms (ABLs and ships) cannot cover. It did not address other concepts or how they would operate in concert. The challenge seems clear. The viability of the concept, especially for the long term, depends critically on speed-of-light weapons with ranges of 100 km or more. The concept may be viable with very fast interceptors (e.g., 5 km/sec), but here we are at the ragged edge of footprint in the presence of enemy missiles with short burn times.

Capabilities and Technologies We Need

- The Air Force needs a UAV with a sizable payload that can persist over enemy territory. With regard to survivability we have the following advantages: (1) the UAV is at very high altitude; (2) it is LO; and (3) our SEAD UAV is protecting it from radar controlled SAMs by preventing acquisition radars from establishing a track on our CELM UAVs.
- We need speed-of-light weapons—directed-energy weapons or cyber-type weapons—with lethality ranges of 100 km or more.
- Absent the above weapons, we require missiles for the weapons on our UAV. These weapons must be capable of high speed (5 km/sec) and weigh no more than 750 lbs each while carrying a 200-pound payload.

E.2.2 Counter Cruise Missiles

Statement of the Operational Task. Cruise missiles that are launched will be destroyed before they exit enemy territory.

Introduction. The likelihood of enemy employment of cruise missiles in future hostilities has significantly increased due to their demonstrated effectiveness in Desert Storm and their ready availability at relatively low cost compared to that of aircraft and theater ballistic missiles (TBMs).

Cruise missiles are widely proliferated, with over 70,000 of more than 65 types in countries other than the United States. Over 30 new or modified versions are estimated to be in various stages of development. Most are inherently low observable (LO) because of their small size,

and application of elementary signature technology can further reduce their radar cross sections. While most cruise missile payloads are unitary conventional warheads, some carry cluster munitions; and in the future, WMD payloads should not be discounted.

Cruise missiles can be air-launched from a carrier aircraft (bomber, transport, or fighter), and sea- or ground-launched with rocket boost. They can also make a take-off similar to that of a UAV. The problem of cruise missile detection, intercept, and neutralization is compounded by the variety of their flight profiles, which spans from 70 kts to near-sonic speeds, nap of the earth to 40,000 ft altitude, and ranges in excess of 500 NM.

Triggering Event. This task will be implemented in response to a determination that a nation or group has the capability and intent to threaten U.S. national interests and that this hostile entity possesses cruise missiles.

- Cueing Events

  Various intelligence means, including HUMINT, SIGINT, and overhead reconnaissance, will provide triggering information which includes:

  - Acquisition of cruise missiles from a known supplier
  - Indigenous production and/or assembly of cruise missiles
  - Tests of cruise missile and/or launcher systems

Assumptions

- Rules of Engagement. If it is ascertained that enemy cruise missiles have WMD payloads, preemptive strikes at cruise missile launch/storage areas may be in order.

Summary Description of the Operational Concept. (See Figure 8.) The first key to countering cruise missiles is the foreknowledge of their types and thus their flight characteristics/ profiles—i.e., low or high altitudes/airspeeds. This should be ascertained via intelligence means. The second key is knowing when they are launched. For rocket-boosted ground or sea launch, U.S. surveillance assets to be utilized for detection of TBM launches can provide the information cueing. In the air-launch case, the carrier aircraft becomes the primary target. Ascertaining the conventional runway takeoff of a cruise missile is more problematical. UAVs with SAR/GMTI may assist in cueing of slower targets.

After-launch detection is done via surveillance radar, which provides cueing to fighters until they acquire the cruise missile(s) and then attack with missiles that have multimode seekers.

Elements of the Concept

- Satellites and/or UAVs with EO/SAR/GMTI will be used to detect cruise missile launches. This information will be passed to surveillance platforms.
- Surveillance platforms will acquire and track the cruise missiles and vector the (fighters) for intercept. The fighters will acquire and employ radar guided missiles to kill the cruise missiles.

Counter Cruise Missiles

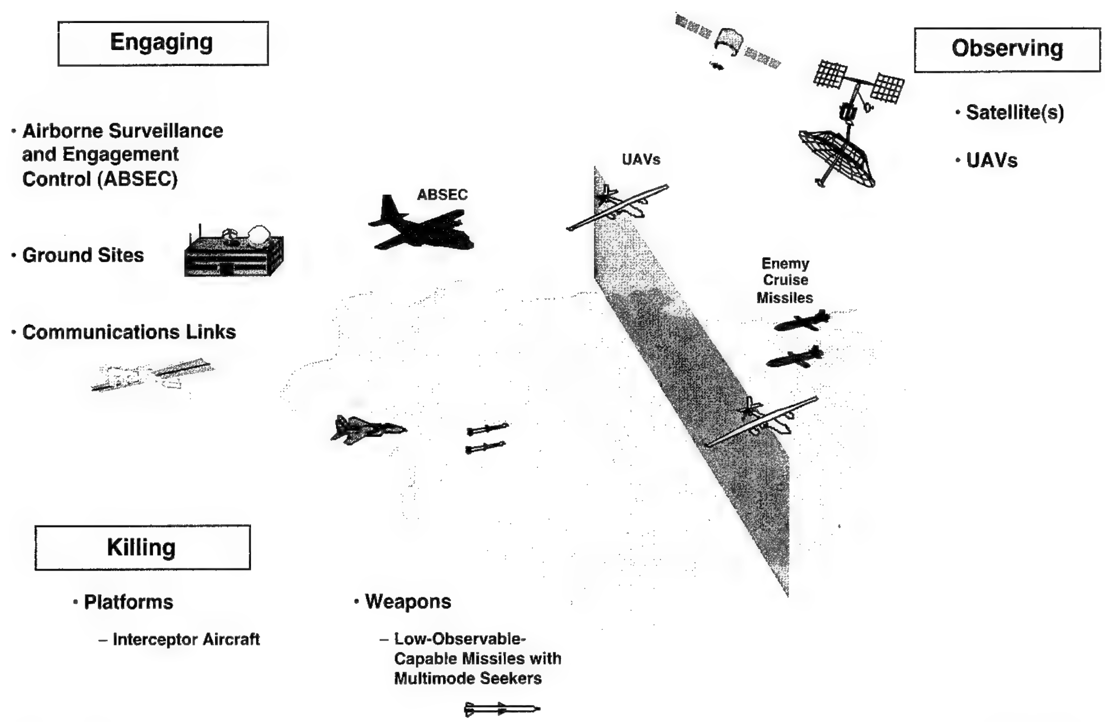

Figure 8

Capabilities and Technologies Needed

- Surveillance and fighter fire-control radar systems that have the capability to detect LO air vehicles in a clutter background at operationally relevant ranges.
- Air-to-air missiles that are effective against the above targets.

E.2.3 Prohibit Use of Civilian Facilities for Military Purposes

Statement of the Operational Task. Any noncombatant facilities (manufacturing plants, schools, churches, hospitals, etc.) being used for forbidden purposes will be quarantined and disabled. Any attempt to break the quarantine will be dealt with appropriately.

Introduction. Experience has shown that a potential adversary will try to hide the manufacturing and storage of restricted weapons and other critical military functions. Military products and functions have been produced and collocated within civilian facilities—e.g., the Iraqi "baby milk factory." Currently, over four hundred targets worldwide have been identified that are associated with the production, storage and control of weapons of mass destruction.

Many of these targets are collocated with, or are in close proximity to, civilian facilities like hospitals, schools and churches. The use of civilian facilities for prohibited military use cannot be allowed to go unpunished. A U.S. response against facilities being used for prohibited purposes must be effective and be carried out in a manner that does not result in civilian casualties.

Triggering Events. This task will be triggered after sufficient information has been gathered and assessed to indicate beyond a reasonable doubt that a given facility is being used for a prohibited purpose. The prohibited use of the facility could be of sufficient severity to pose a clear threat to U.S. national security. If the activities being conducted within a civilian facility are declared a threat to national security, actions requiring military forces may be needed if the situation cannot be resolved by diplomatic means. The triggering events leading to military action include sensing of industrial byproducts associated with the prohibited products coming from the facility in question, intelligence data from multiple human intelligence (HUMINT) sources, electromagnetic emissions peculiar to the product or function, and stated intent or overt actions by the offending country or group.

Information from multiple sources will be fused and assessed, and a decision will be made by the President, in conjunction with the NCA, to take action. The decision will be transmitted to the proper military command authorities for implementation. Operational plans will be drafted and approved. The appropriate commanders and force structure will be assigned to the task. The mission will be conducted and the results identified and assessed. The outcome of the mission will be communicated to the President and the NCA. If the results are satisfactory to the President, the mission is completed. If the results are not satisfactory, new directives will be drafted and issued to the appropriate military authorities, or further action will be terminated.

Assumptions. It is very important that the rules of engagement for this task be accurately defined. It is necessary that the potential capabilities of the offending country or group be perceived as such a grievous threat to national security that action must be taken. When action is taken, it must be decisive and preferably result in no civilian causalities. No U.S. causalities are considered acceptable, and no U.S. military personnel must fall into the hands of the offending country or group.

Summary Description of the Operational Concept. (See Figure 9.) Satellite reconnaissance data indicate that a civilian facility located in a foreign country may be a possible source of prohibited manufacture of chemical-warfare agents or may be conducting another military function that constitutes a severe threat. There is enough data available to justify full time surveillance of the facility in question. Long-duration low observable surveillance UAVs are deployed covertly in close proximity to the suspected facility to monitor activities in and around the facility. The initial assessment of intelligence data is verified. Diplomatic initiatives have not produced the desired outcome, and it has been decided by the President to quarantine and if necessary destroy the facility to eliminate the threat.

Weapon-carrying UAVs are added to the surveillance UAVs. An aircraft “cap” is added outside the borders of the offending country to provide additional firepower. This “cap” is equipped with long-range hypersonic standoff weapons to interdict anyone trying to break the quarantine by military force. Because of the location of the facility in a highly populated civilian residential area, it is decided not to use air-delivered weapons to destroy the facility. SOF will be used to dismantle the facility under the cover of a quarantine. SOF are deployed after low

observable UTAs saturate the immediate area of the facility with nonlethal "sleep inducing" agents. The SOF are landed close to or on the facility. Any civilians that may have been in the facility are removed, after which the SOF proceed to dismantle the production equipment, remove any products that have been produced, and raze the facility. The SOF are extracted, and the quarantine is lifted.

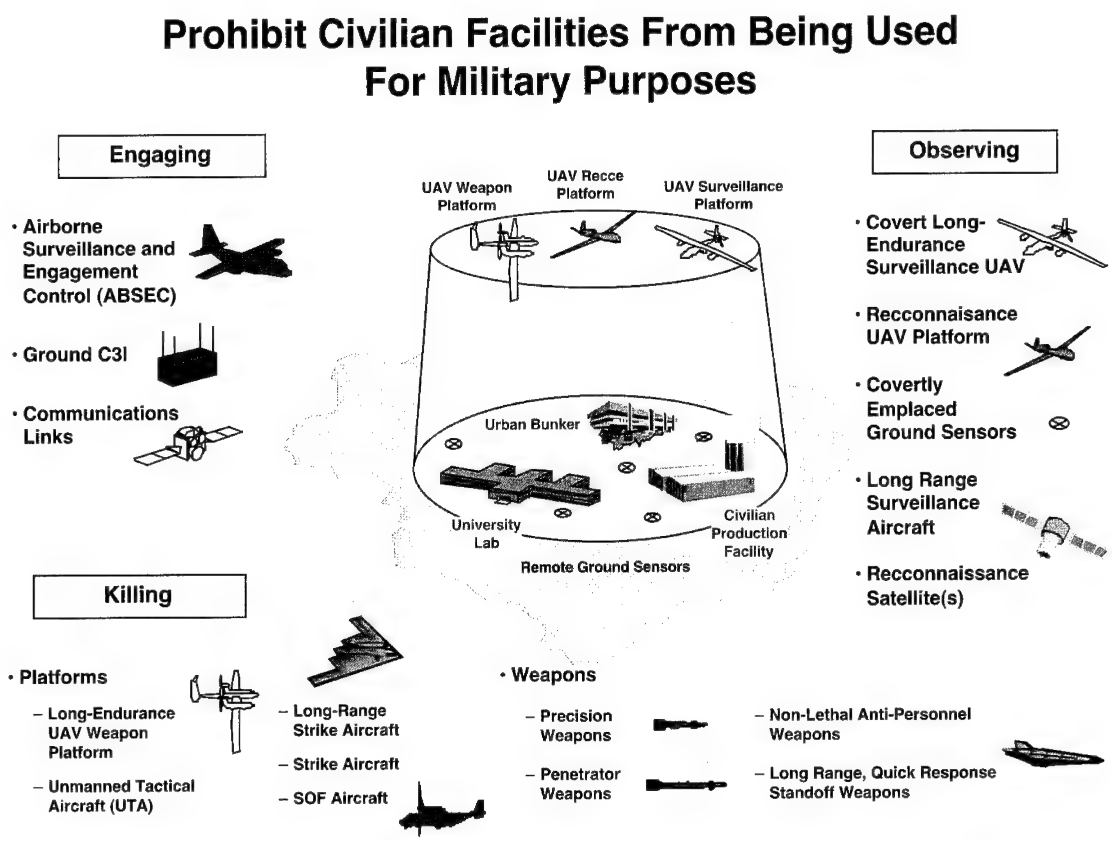

Figure 9

Elements of the Concept

- Determine that a civilian facility is being used for forbidden military purposes.
- Define the actions to be taken and issue the orders to the military forces.
- Quarantine the facility in question.
- Prevent the quarantine from being broken.
- Disable the production and storage of the products or the military function(s) in question.
- Lift the quarantine and declare the action over.

Capabilities and Technologies We Need. To carry out this operational task, it is necessary that a variety of remote sensors and sensor platforms be used. The sensors must be capable of producing high-resolution (SAR, IR, visible) images and of monitoring electronic, chemical, biological , and radioactive emissions. Positive identification of the content, precise layout, and environment surrounding the facility in question is needed. These sensors must be compatible with UAV, TAV, aircraft, satellite and remote ground platforms.

Sensors located on enduring, covert platforms are needed to unambiguously identify the products emitted from these facilities, both before and after the task is completed. Enduring platforms that provide a "cap" over the facility are essential prior to the attack, during the attack, and after the attack. The facility must be kept under continuous surveillance throughout the duration of the quarantine. If weapons are employed to destroy the facility, the material within the facility must be contained to prevent potentially catastrophic collateral-lateral damage. If nonlethal antipersonnel weapons are used, there must be no residual negative effects on civilians. Throughout the conduct of the task, secure dynamic force control must be maintained. All information essential for each element of the military forces employed to conduct their assignments must be continuously supplied to the right people at the right time.

E.3 Suppress Enemy Air Defenses (SEAD)

Statement of the Operational Task. Air defense batteries will be neutralized before they can complete an engagement against friendly platforms.

Introduction. The Air Force assiduously seeks to protect its platforms, particularly from radar-controlled SAMs. These platforms include the following:

- UAVs or UTAs on combat air patrol (CAP) at very high to high altitudes over enemy territory engaged in such tasks as reconnaissance, surveillance, and boost-phase intercept.
- Aircraft at high to modest altitudes engaged in such tasks as enforcing no-fly zones; halting the movement of men, trucks, tanks, and armies; suppressing enemy artillery and other ground-launched weapons and attacking "strategic" targets.

Triggering Event. Prior to employing U.S. attack aircraft, UAVs, or UTAs, there will be a determined attack by F-117s and B-2s with IGPS weapons against all known locations of early-warning and acquisition radars as well as an attack against all located SAM batteries. However, some radar sites and SAM batteries will be missed. The triggering event for defense suppression efforts is that one of the remaining early-warning or acquisition radars begins transmitting.

Assumptions. One assumption is that the rogue government had few radar sites (EW and acquisition) in the first place. In addition, our attack, prior to deploying the attack aircraft and combat support aircraft, is assumed to be quite successful and thus few radars are left.

Summary of the Operational Concept and Elements of the Concept. (See Figure 10.) In general, the concept is to concentrate on the search and acquisition radars, and it involves putting a "cap" over a designated area. Any search or acquisition radar that attempts to transmit within that area will be neutralized almost immediately after it radiates and before operators can

establish a track. If the operators cannot establish a track, there is no hand-off to a target-track radar, and surface-to-air missiles remain on their launchers.

Suppress Enemy Air Defense (SEAD)

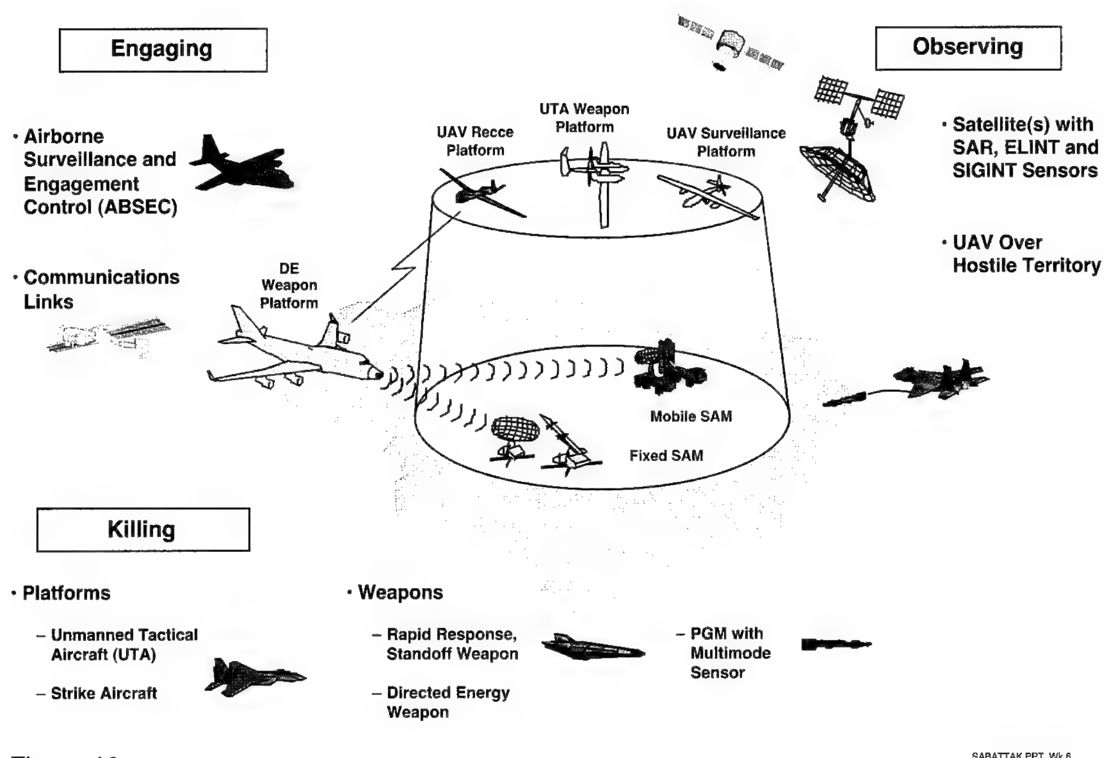

Figure 10

The operational concept for enforcing this “cap” is as follows:

- The Air Force deploys enough high-flying UAVs to “cover” a designated area. The number of required UAVs will depend on the size of the area and on the “footprint” of each UAV.
- Observing the Triggering Event and Locating the Target

  The UAVs are equipped with sensing systems that observe the signal from each radar (search and acquisition). A sensing system does two things quickly: it identifies the type of radar, and it determines the geolocation of the transmitter. These measurements of location must be accurate enough to ensure that the “location basket,” as determined by the sensors, is compatible with the terminal engagement and kill functions, as determined by the weapon capabilities.

  One way to establish geolocation is as follows. By virtue of a precision-differential global positioning system (GPS), each UAV knows its position. An interferometer

provides the angle to the radar. From an onboard database, the elevation of the earth can be calculated at the point on the earth where a line at the determined angle intersects the earth. Thus, based on multiple observations from one platform, the position of the radar (the transmitter) on the earth can be calculated.

The accuracy of angle measurement is probably limited to two milliradians. This may be sufficient for some types of terminal engagements—e.g., engagements with ARMs. However, if weapons with submunitions such as bomblets are to be used, greater accuracy may be desired.

As an alternative, devices could be placed on several UAVs to measure the time of arrival of a particular part of a pulse. By observing the difference in time of arrival at three different pairs of UAVs, geolocation of the radar could be determined quite accurately—probably within less than 20 meters CEP. There remains some controverisy regarding which concept—interferometers or time difference of arrival TDOA—is more accurate. Until the contrary is demonstrated, the panel's operating assumption is that we will use interferometers—partly because they are operationally more simple.

- The Footprint

  It is desirable that each UAV have as large a footprint on the ground as possible. Tentatively, we stipulate that each UAV will "engage" any radar that is within a cone below the UAV whose half-angle is 75 degrees. At 30 km altitude, this provides a footprint on the ground of a circle of 100 km in radius. The slant range to the target at this angle would be approximately 120 km. At such ranges, missiles with warheads may take too long to get to the target. On the other hand, directed-energy weapons may lack the power to kill targets at that range.

- Killing the Target

  A few seconds following the triggering event (a radar transmittal), a weapon is launched from the UAV or UTA toward the radar. If the weapon is a missile, it should not weigh more than about 750 lbs. Most important, the missile must have a high velocity—at least 5 km/sec. This may be possible because gravity is on our side. However, aerodynamic heating is not. The missile should be equipped with an inertial unit, a HARM-like seeker, and a small unitary warhead. Alternatively, it may be equipped with small bomblets or SFWs.

  Once launched at a slant range to the target of 120 km, the missile will require about 25 seconds to reach the target if it is capable of very-high-velocity speeds (5 km/sec). If the radar continues to radiate for about the same period, the missile "homes" on the antenna, and the small unitary warhead does its job. However, the radar may turn off before the attacking missile arrives. To guard against this contingency, another weapon is launched, this time an inertially guided dispenser equipped with smart antitank weapons (e.g. LOCAAS, BAT). They are dispensed at the proper altitude, and the terminal engagement is completed according to their logic. Alternatively, the inertially guided dispensers could be equipped with bomblets or SFWs.

- An Alternative Weapon

  Even with the fast missile described above, about thirty seconds is required to get the kill mechanism to the target. By then, the radar could have established track on one of our aircraft. Although the radar may not live to track again, we have not denied "first launch." Thus, we must examine alternative types of weapons. SEAD UAVs or UTAs could be equipped with a directed-energy weapon. This achieves the right speed but inherits a problem of depositing enough energy in a short period of time. However, achievable RF power levels should suffice to disrupt the operation of the radar long enough to allow a missile to destroy it. Ideally, the RF attack will confuse the system operator and prompt him to continue transmitting, thus helping an ARM hit its target.

  As already indicated, directed-energy weapons solve the time-of-flight problem but retain the problem of generating enough energy in a UAV to destroy a radar at a distance of about 100 kilometers. Thus the tradeoff is that the smaller the area of regard of one UAV, the more vehicles are needed to establish the "cap." This argues for a larger UAV with more power and perhaps a larger footprint. The larger the footprint, the fewer UAVs required to establish the cap.

- Another Alternative Weapon

  With high explosives (HEs) as the source of energy, we are "time limited." We have sufficient energy, but we cannot get the HE to the target quickly enough. With directed-energy weapons, we may be "power limited." We can get the energy to the target rapidly but may be lacking in power at useful distances from the platform to the target.

  A weapon is required that travels with the speed of light but does not depend on depositing large amounts of power to create force fields that cause physical damage. Instead of neutralizing the unit with broadaxes we will do so with small doses of poison to its nervous system. For want of a better name, we will call this type of weapon a "cyber" weapon, which operates on the nervous system of its victim. Here, the challenge is to get small amounts of energy into exactly the right place—the nervous system of the unit (circuits, chips, etc.) we seek to destroy.

An Overall Perspective. The overall concept depends on the idea that if enemy search and acquisition radars (transmitters) can be destroyed or neutralized in a very short time (seconds), then operators cannot "hand-off" target tracks to SAM batteries and target-track radars. Without the "hand-off," target-track radars cannot find the targets, and our platforms are safe, at least from this threat. Moreover, because we are after all transmitters, our concept still applies even if the enemy resorts to bi-static systems.

This means that we must have the capability to engage all search and acquisition radars that can possibly "paint" the platforms we are trying to protect: UAVs engaged in surveillance of enemy activities, attack aircraft and bombers engaged in halting invading armies, UTAs engaged in suppressing enemy artillery, and UAVs or UTAs engaged in a "cap" to intercept enemy ballistic missiles during the ascent phase.

How large an area to "cap" would, of course, depend critically on the radar cross-section of the platforms we seek to protect. That is, we do not have to engage radars that are so far away they cannot "paint" the platforms we are protecting. Thus, there is a tradeoff between the observables of the platforms we are protecting and the number of SEAD UAVs required.

As indicated earlier, the assumption has been made that U.S. forces will not be required to engage large numbers of enemy search radars. All known sites within the designated area will have been attacked decisively beforehand. The only radars to be engaged are those that were not in the database and therefore escaped attack.

Capabilities and Technologies We Need

- UAVs that can carry a sizable payload, persist over enemy territory, are low observable, and fly high.
- Devices that can determine the AOA and the geolocation of enemy radars very accurately and quickly. Current devices may, in fact, already be adequate.
- A speed-of-light (directed-energy) weapon that can quickly deposit sufficient energy into a radar unit to damage or disrupt it from distances of approximately 100 km. There is a tradeoff between longer-range weapons and fewer UAVs to establish the "cap."
- Alternatively, "cyber" weapons to neutralize radar transmitters from platforms many kilometers away.
- Missiles that travel at very high speeds, although even with fast weapons, we have not necessarily achieved the stated task, which is to prevent even one launch, thereby keeping all enemy SAMs on their launchers.
- An overall concept for a surveillance system, with appropriate processing capability, that can provide a database for a successful attack of the enemy's radars, SAM sites, and control nodes.

E.4 Neutralize Hostile Space Operations (Deny Information to the Enemy)

Statement of the Operational Task. If enemy spacecraft operate in forbidden ways, or if commercial satellites are used in adversarial ways, they will be selectively neutralized.

Introduction. These two tasks are essentially the same, although neutralization of enemy satellites would occur after a declaration of hostilities, with the result that certain spacecraft would be designated "enemy," as opposed to "friendly" or "commercial." The designation of "enemy" eases the problem to some extent in that responses to hostile acts are not constrained by treaties and therefore slowed by the time required to interpret them.

Specific Objective. The U.S. military seeks to temporarily or permanently deny an adversary access to imagery, communications, and navigation information, thus reducing the potential to affect military or other operations being conducted by the United States on behalf of itself or an ally.

Operational Tasks

- Degrade a power system on a satellite—e. g., damage a solar panel
- Damage or destroy an imaging system
- Disrupt command or data links
- Upset attitude control so that a satellite doesn't aim at the right point in space

Both the commercial world and the U.S. military depend heavily on GPS for navigation, SATCOMs for communications functions, and imaging systems for weather monitoring. Therefore, great care must be taken to understand how actions are likely to affect populations and activities of entities other than the "enemy" to whom information is being denied. These operations must be extremely covert.

Characteristics of Targets. "Enemy" satellites provide imagery, navigation and communications services. They fly in a range of orbits and are owned and operated by a variety of governments and companies.

The physical characteristics of these satellites can be obtained from intelligence sources and, for commercial systems, from the open literature. It is important to know the exact functions the satellites perform. In addition to understanding how they perform their primary mission(s), it is also important to be familiar with their ancillary and necessary support functions— e.g., navigation or power. If denied, these support functions can also affect the satellite's performance. If a satellite images, how many cameras does it have, where are they located and what are their characteristics? If the satellite has an antenna for receiving data, where is it located and how is it constructed? If it has a transmitter for sending data/information, where is it located and how is it constructed? Where and what is the attitude reference system?

Orbit characteristics must also be precisely determined and cataloged in a database that is maintained in real time. This database must be accessible to those who must make a determination regarding "attacks." The system must be very high speed and user friendly; that is, no special computer skills should be required to read it and obtain information from it other than proper security passwords.

A final and important set of target characteristics deals with maintaining knowledge of who the subscribers are for the satellites' services—including U.S. subscribers—and what they rely on the satellites to provide. What will the subscribers do if the information is denied? How will they know if it is denied? Can effects be temporary, or are they likely to be permanent? If permanent, will the satellite simply be degraded or will it completely cease to function?

Grave consequences may occur if these actions are detected against either friendly or hostile systems. What would the United States do if denied similar services and what countries or other entities have the ability to deny us? (Denial could take the form of attacks on ground stations, which the United States would probably consider an act of war.)

To commit to this operational concept, the United States must have thoroughly considered the consequences of potential acts before they are undertaken and then, having considered all possible outcomes, act accordingly. While covertness must always be the watchword, discovery

can and is likely to occur. However, if the task is of extreme importance, the nation must be prepared to act and then deal with the consequences.

Triggering Events. Triggering events are situation dependent. For example, if the United States plans to conduct a covert operation or a "surprise" attack of some type, it will be important to protect communications—i.e., achieve a high degree of communications security. It will also be important to deny observation of a jump-off point, marshaling area, deployment preparations, aircraft taking off and landing, etc. We need to know if the countries we are mounting the operation against subscribe to imagery, communications and other systems that can jeopardize the success of our operation. It will be important that the operation go unobserved.

These are crucial matters to both the United States and any country we might be protecting. The President, National Security Council (NSC), and JCS would have to decide that access to the services must be denied for a specific period of time. Denial could take the form of a system failure that is recoverable, or it could take the form of varying levels of system damage that would result in anything from partial loss of capability to full system shutdown.

- Cueing Events

  Cueing events are dependent on circumstances and would be determined at very high levels of command. All satellite launches worldwide must be monitored and cataloged. Orbital data must be maintained in real-time. Subscriber names and usage must be obtained and maintained in real time. If at any time a subscriber's usage increases dramatically, this should be viewed as a "cueing" event and brought to the attention of someone qualified to assess its meaning. It may signal harmful intent and cause the United States to seek other intelligence information about the subscriber to determine the meaning of the increased usage, particularly if any type of heightened tensions exist in the affected region. Moreover, if a country carries out a hostile act against another country, the United States should increase the frequency of its review of satellites those countries are using as a possible indication of some additional malevolent activity.

- Decision and Command Process

  Decisions will be made at the presidential, NSC, and JCS level.

Summary Description of the Operational Concept. (See Figure 11.) Ground-based systems precisely track all of the world's orbiting satellites, providing input to a real-time database to be used in targeting. These systems, perhaps augmented by others, also maintain a real-time database on subscribers and their usage rates to be used for indications and warning (I&W), as well as a detailed description of the satellites' vulnerable components.

Once it has been decided that information from a satellite must be denied, the following actions must be taken.

- Determine what information must be denied, for how long, at what point in time. For both the United States and the subject country, determine the consequences of the denial in terms of lost services.

- Assess the possibility that access denial will be detected and determine the possible consequences (retaliatory acts) that might occur.

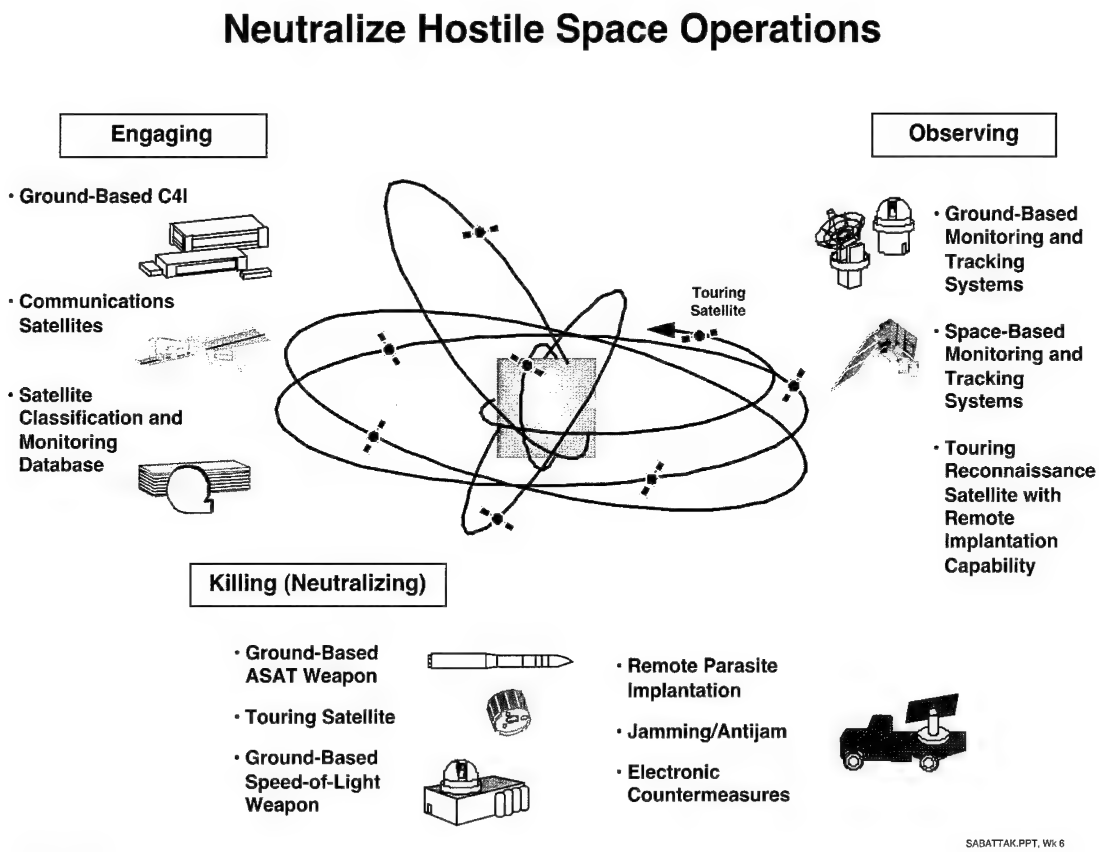

Figure 11

- Using very precise, swift, and covert neutralization techniques, carry out the "attack" against the satellite(s). Provide a cover of plausible denial.

Elements of the Concept

- Signatures: Electro-optical, SIGINT, orbits, usage, subscribers.
- Time sensitivity, target characteristics, countermeasures: Operations are very time sensitive. The target is soft with distributed and perhaps shielded components. Countermeasures could include deception to indicate a system location that isn't there (e.g., a camera) and a system that would detect an energy flux or other form of interference and transmit this information to the subscriber/owner, enabling him to determine if an attack had occurred, from where, and by whom.
- Platforms for sensors and weapons: Sensors can be on the ground or in orbit. Weapons can be on the ground or in orbit.
- Attack assessments: Attack assessments may be either functional or physical. If the functions the satellites are performing can be monitored in real-time—e.g., communications—and if the usage decreases markedly, the mission is probably successful. If the task is to interrupt the satellite's attitude control, real-time

monitoring of the satellite's orbit will indicate that. If the task is to reduce power or damage an optical system, observation of the user over time, including his behavior, may be the only indication of the success of the mission. If the task produces physical damage to an external system, it may be visible to a very-high-resolution optical observation system. If satellite telemetry can be intercepted and interpreted, it may provide details of system health and status.

Capabilities and Technologies We Need

- Ability to monitor and precisely track all the world's satellite systems, including subscribers and usage.
- "Lethality" assessments for various types of kill mechanisms, including an assessment of the likelihood of the attack being detected—i.e., what indicators will exist.
- "Weapons" that can be employed covertly from space and/or ground platforms.
- Exercises/wargames for the NCA to allow exposure to difficult decisions that will require time to make. Timing will be critical; there is a great need to operate inside the enemy's decision cycle. The NCA's first exposure to such decisionmaking processes should not occur when the demand for the decisions is real.

E.5 Counter Invading Armies Quickly

Statement of the Operational Task. Develop the ability to swiftly attack and dominate any battlefield.

Introduction. Our systems will enable surprise attack and intense sustained, highly lethal attack. Our objective is speed. We will be much faster than the enemy in every phase and every element of the battle.

Specific Objectives. If enemy forces move on the ground in forbidden areas, they will die before they reach their objectives. If enemy land forces move to occupy territories or bases in forbidden areas, the U.S. military will cause them to leave or promptly destroy them. These objectives will be achieved by a high-intensity surgical attack against a dynamically prioritized target list.

Characteristics of Targets and Environments. The targets will include all elements of modern mobile land forces—e.g., tanks; artillery; mobile infantry; mobile command, control, and communications equipment; attack helicopters; and mobile air defense systems. U.S. attack capabilities will be designed and tested for a wide range of environments, ranging from desert to temperate to tropical. Clearly this will stress the design of all systems, particularly the sensor systems.

Triggering Event

- Cueing Events

  In the event of potential hostilities, the enemy will be monitored by a selected combination of satellites, manned aircraft and UAVs. The location of enemy forces,

including individual combat vehicles, will be developed and maintained to an accuracy of 100-200 meters. Selected time histories will be maintained and the attack force will have access to these histories in near real time. Multi-spectural sensor target data will be accumulated and analyzed using a new generation of algorithms. We will exploit many signatures: optical (visual), IR, radar, electromagnetic emissions (planned and inherent), and digital information extracted from enemy data systems and other sources. Multi-function N-dimensional images will be developed, integrated, and accumulated in databases. Enemy force movement will be evident to attack planners, and to decision makers at all levels,within several minutes after it occurs. Analysis of cueing event data will be heavily computer assisted.

- Sources of Triggering Information

  Satellites, manned aircraft (such as JSTARS II), and long-endurance UAVs will be the primary sources of triggering information. No ground force will be able to hide and execute a surprise attack in the classical sense. In most cases, extremely survivable UAVs with multispectral sensors will be deployed over the enemy.

- Decision and Command Processes

  Selected near-real-time data will be available to the NCA. The theater air commander and his staff (who in most cases will not be in the theater, but in a command post in CONUS) will create the attack plan and modify it in near real time as the information on the enemy evolves. This will be routed in real time via the command data system to all units of the attack force, whether in CONUS or the theater of potential war. When directed by the NCA the attack will proceed rapidly.

Assumptions

- Rules of Engagement

  Within a specified geographical area established by the theater commander, all military targets will be attackable. Once the command decision is made to attack, target locations will be determined to 10 feet or better. All target data will be routed to shooters via secure data links. This will include accumulated multispectral target signature data for each unique target type. If the theater air commander so desires, he can issue target-specific rules of engagement for target types or particular individual targets of special interest. In this case, the target data package transmitted to the shooter will include target-ID criteria, weapons-launch criteria, and any unique ROEs determined by the NCA.

- Dynamic Engagement/Execution Control

  The theater commander will control the overall engagement. At all times, a 72-hour look-ahead ATO will be maintained and disseminated. After the attack begins, a sortie-results database will be created and maintained for each individual sortie, including BDA. Summary data derived from this database will be made

available to the theater commander and the staff. All units in the theater command will also have direct access to this database.

Summary Description of the Operational Concept. (See Figure 12). The designated theater commander will have an integrated force of system capabilities (non-attack assets) and an appropriate mix of attack units and support units. This will include several types of UAVs, manned reconnaissance aircraft, and various specialized attack units, including bombers and tactical aircraft. Once the attack is initiated, it will be continuously planned, executed, and assessed. The total force will be linked by a real-time data system, both in theater and in CONUS. The objective will be surprise, mass of force against weak points, exploitation of terrain, extremely intense operations, and real-time computer assistance everywhere in the force, from theater commander to every individual pilot in every combat aircraft.

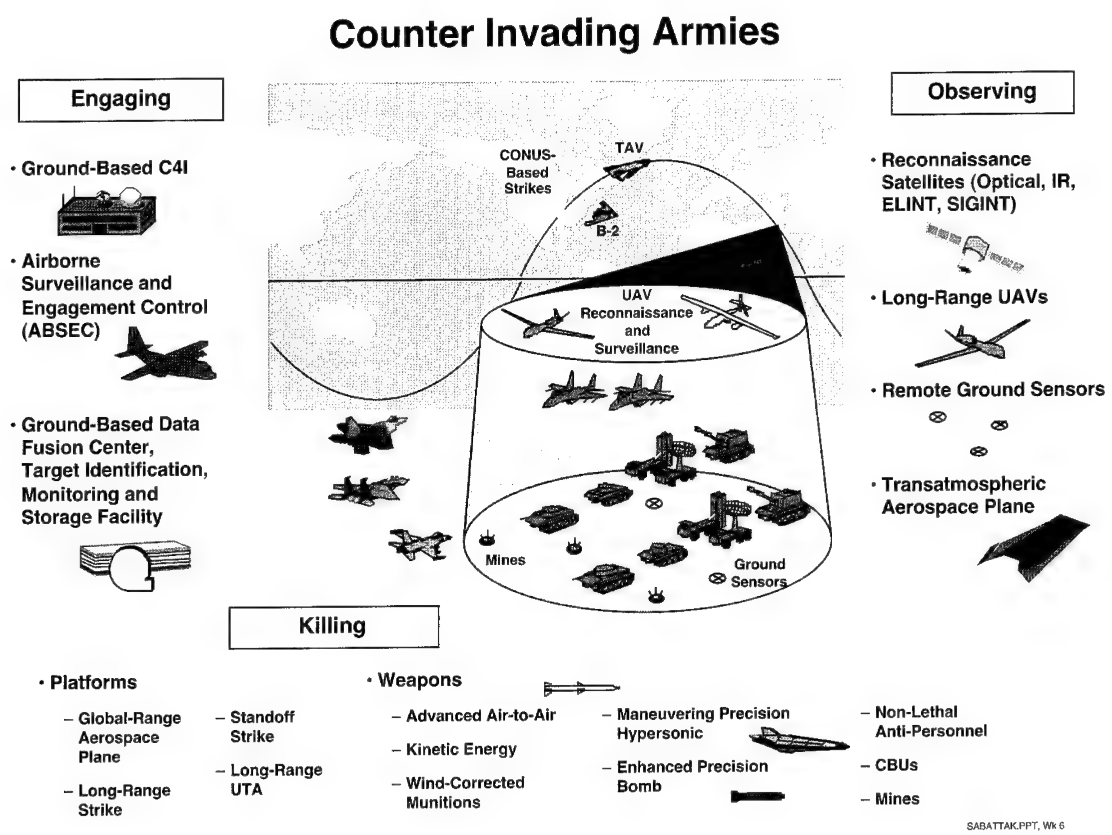

Figure 12

Elements of the Concept. Exploitable signatures/sensors/data are key. For ground attack we will continuously accumulate the multispectral images of all probable ground target types to provide heavily computer-assisted target classification to both the mission planner and to the attack pilot during the attack. This includes the radar sign ature at selected frequencies, visual signature, IR signature, and unique electromagnetic emissions. Consideration should be given

to designing standard, totally integrated multisensor units for UAVs and attack aircraft to minimize cost, weight, volume, and power requirements and to simplify installation. A large collection of platform-unique black boxes is not in our *New World Vista*.

- Countermeasure Resistance

  The fundamental concept is to have a robust attack system that is not solely dependent on any single sensor. Generating effective counter measures against a single sensor is difficult; generating time-coherent countermeasures against multiple sensors is extraordinarily difficult.

- Time Sensitivity

  Force effectiveness is tremendously improved by minimizing all time delays. For example, armored movements are killed very rapidly, never reaching their objectives. The number of sorties per day must obviously be maximized. Critical decision information must move within the force in near real time to maximize effectiveness. Surveillance and reconnaissance data must get to the user in near real time. No attack airplane must ever encounter an unknown SAM site, fixed or mobile.

- Platforms and Weapons
  - A long-range platform for global strike and/or reconnaissance
    - Speed: Mach 3.5 or 5–6 (different engine technologies)
    - Payload: 10,000–30,000 lbs
    - Crew: 2
    - Engines: 2
    - Signature: Low observable
  - A high-endurance, high-altitude, very stealthy UAV
    - Speed: Mach 0.5-0.7
    - Payload: 2000 lbs
    - Sensors: Multiple (2–4)
    - Operating altitude: 80,000 feet
  - A new, very stealthy attack airplane
    - Gross weight: 60–70K lbs
    - Payload: 10–15K lbs
    - Crew: 1
    - Engines: 2
    - Radius of operation: 1000 miles (unrefueled)

- A stealthy, special-purpose attack UAV for selected critical "soft" targets
  - Radius of operation: 500–1000 miles
  - Payload: sensors, 1000 lbs; weapons, 1000 lbs
- A new family of ground attack weapons
  - Standoff weapon: 50–100 mile range; 500-lb payload; internal carriage
  - Precision-guided weapons: 100, 250, 500, and 1000-lb antiarmor weapons

These weapons will use new casings and new explosive technology. They will have two to three times the effectiveness of current weapons of the same weight. Multiple target types (e.g. armor, APCs, trucks) may be engaged by a single weapon type, e.g. LOCAAS.

Capabilities and Technologies We Need

- A reliable, robust theater C^3 system, capable of supporting rapid planning and real-time control of a complex theater war, including near-real-time data on the status of the battlefield down to the individual vehicle. This system will include the capability to conduct realistic simulated theater war campaigns.
- High-endurance, very survivable stealthy UAVs to monitor the enemy with very high precision prior to hostilities and for the duration of the attack. This system will require a very efficient engine for operation at 80,000 feet or above.
- A family of standardized secure data links to integrate all elements of the force in near real time.
- Very accurate all-weather sensors:
  - Recce sensors: 100–200 ft accuracy
  - Attack sensors: 2–10 ft accuracy
- For certain contingencies, a CONUS-based hypersonic (Mach 10) strike aircraft is highly desirable. Long time delays from decision to attack are not consistent with high-credibility conventional deterrence. Global presence must be closer to real time.
- A totally new family of smaller, lighter-weight, high-precision attack weapons. The feasibility of achieving at least twice the explosive power per pound has been established. The ability to engage multiple target types with a single weapon has also been established. Implementing this technology has tremendous leverage.

E.6 Suppress Hostile Artillery

Statement of the Operational Task. Enemy operators of weapons (rifles, artillery, mortars) that fire rounds into a specified area will be neutralized. They cannot shoot and hide.

Introduction. In Bosnia, we have seen UN (and particularly U.S.) forces crippled by their inability to guarantee the President and other decision makers that, once detected, artillery positions can be neutralized with little or no collateral damage. If collateral damage had not

been an issue, the order would have been given. In this case, collateral damage would have resulted in political damage and probably in more carnage directed at the populace.

Specific Objective. The objective is to detect and build time history files of the subject weapons so that, at any given time, their position is known accurately enough to apply precision weapons to the enemy weapons before they can move to another location.

Characteristics of Targets and Environments. The targets are lightly armored vehicles or towed artillery pieces. Therefore, they are subject to damage by any weapon capable of damaging a tank. Towed artillery pieces present a special type of target because either the tube itself (a small, hard target), the personnel manning it, or both must be hit.

The environment is situation dependent. It may be hilly countryside with heavy vegetation. It may be open fields. It may be desert. However, in situations such as the conflict in Bosnia, the enemy would make his weapons difficult to locate no matter what the characteristics of the adjacent terrain. Furthermore, he may also attempt to extract a price from us, if our attack is not successful. For example, he might locate his weapons in urban areas, adjacent to "neutral" facilities such as hospitals, orphanages, etc. Such a strategy would make the weapons difficult to detect by traditional means and would require very precise attack.

Triggering Event. The triggering event is the firing of artillery or other guns from hidden and/or forbidden areas. The event is detected visually by ground observers, by back-track radars, flash detection, and/or communications intercept.

The decision process must start before the first round is fired. That is, it must already be agreed that the "attack" systems we possess are so accurate in their detection and classification of the target ,and the weapons so accurate, that the rules of engagement are "fire on detection." The "controller" must be in the chain of command so the order to fire can be given in the shortest possible period of time.

Assumptions. If the gun shoots and is detected, an attack is laid on instantly. Engagement control is carried out in a way that links the sensor, assessor, and controllers to each other and to the shooter so the task can be accomplished within set time limits. In this case, the time limit is on the order of five minutes or less in the most stressing case.

Summary Description of Operational Concept. (See Figure 13.) This concept requires real-time detection of the weapons being fired, a real-time time history database of the location of any weapon that has ever fired, and the ability to bring very precise attacks to bear within five minutes or less after firing is detected. The sensors must be able to detect and classify the targets in complex backgrounds. The offensive weapons must be able to hit precisely and obtain the desired effect.

Elements of the Concept

- Sensors include airborne ground-target surveillance and engagement systems with GMTI; UAVs carrying ultrawideband, low-frequency foliage penetration (FOPEN) radars; or UAVs with "historic" radars whose target locations are being continuously updated. This assumes we will continuously saturate the area with surveillance platforms to build a database of target locations. Sensors for detection of firing include ground observers with GPS and ranging devices, backtrack radars

on the ground, UAVs equipped with flash detection systems, and communications intercept systems.

- Assessors and controllers may be either airborne or ground based. They must have communications that link them in real time to the sensors, They must have the ability to display fused data, and they must be in the chain of command.
- Platforms may be UAVs, unmanned tactical aircraft (UTAs), or manned aircraft. They may also be dismounted SOF.
- Weapons include smart munitions (e.g., LOCAAS); wind-corrected munitions dispensers with smart submunitions; unitary weapons with differential GPS guidance coupled with a passive terminal seeker; and cruise missiles with mixed payloads to enable attacks against fixed or moving targets. There must also be weapons that are effective against personnel where effects include temporary incapacitation rather than killing.
- Attack assessment would be accomplished via the real-time time history, ground observers, and UAVs performing surveillance of the battlefield with high-resolution SAR.

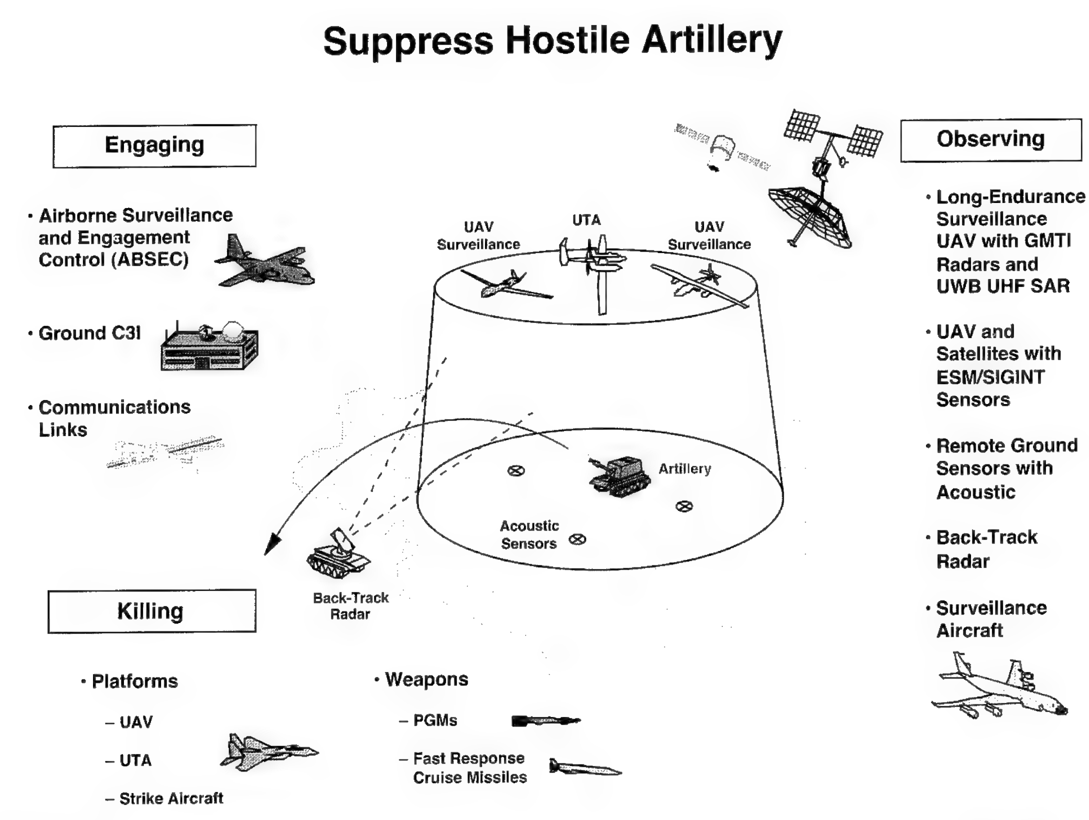

Figure 13

Capabilities and Technologies We Need

- Sensors that can detect and classify these weapons in complex backgrounds.
- Sensors and platforms that can provide continuous, real-time surveillance and time histories.
- A dynamic engagement control system that ties the sensors, assessors, controllers and shooters together in such a way that the response time of the attack is shorter than the gun's shoot-and-scoot time.
- A shooter that can respond quickly and survive.
- Weapons that are very precise, have high speeds, and produce desired effects with little or no collateral damage.

E.7 Defeat Enemy Air Forces

Statement of the Operational Task. If enemy aircraft (or UAVs) are deployed or operate from forbidden bases, the bases and aircraft will be destroyed before they can accomplish their missions.

Introduction. The Air Force of the 21st century will be expected not only to conduct classical air superiority and counter air missions but to do so swiftly, with little "build-up" opportunity and in the context of a broader spectrum of military scenarios, from limited contingencies to full-scale conventional and nuclear war. When possible, these missions will be carried out with minimum collateral damage.

Objectives. To build this required capability, the Air Force must develop an integrated "sensor-based" information system to determine accurate deployment of potential enemy aircraft and to destroy or neutralize these forces prior to launch or, if airborne, to intercept and destroy enemy aircraft as soon as possible after launch. This capability should include a special operations capability with stealth aircraft as well as ground-attack assets to destroy and/or close enemy bases.

Characteristics of the Targets. Targets will include air bases and supporting infrastructure—i.e., runways and taxiways, maintenance facilities, power, C^2 facilities, and POL. It will be necessary to study and understand thoroughly the weak points of the air base infrastructure—e.g., power, fuel, C^2—and optimize attacks on these areas. Standoff weapons and UAVs carrying runway penetrating weapons with mines should bedeveloped with accurate GPS, inertial and SAR scene-matching guidance to provide near-zero CEP (< 1m) accuracy. Critical support radar and communications links may be attacked by SOF.

The mission of denial of forbidden air bases can be expected to be carried out both from the continental United States and from a few staging bases—e.g., Guam, Diego Garcia. Targets include fighters, support aircraft, and UTAs that may be revetted and protected with varying defenses (AAA, SAMs, or aircraft). Neutralization of these defenses using jamming, information denial techniques, and destruction is critical. Standoff weapons delivered by friendly aircraft or UAVs are necessary. The present need to overfly a runway target results in excessive losses. Therefore, UTAs have great potential, and a family of them should be considered.

Manned aircraft will engage any enemy aircraft and UAVs that become airborne. Our forces will require beyond-visual-range identification (BVRID) techniques that surpass today's IFF. A variety of methods, from familiar techniques such as jet engine modulation to complex pattern recognition algorithms applied to patterns of scatterers on enemy aircraft, may be used to achieve high confidence BVRID.

Triggering Events

- Cueing Events

  The deployment activity of enemy aircraft to forbidden bases should be determined from indications within the enemy political and military infrastructures. Triggering and supporting sensor cues include not only troop and vehicle movements, but less obvious actions within the monetary and business sectors. These cues must be discerned as early as possible and intelligence sensor programs activated.

- Sources of Triggering Information

  If response action cannot be initiated until launch of enemy aircraft, then satellites and other aircraft should use their sensors to determine the type and nature of enemy aircraft. Positive ID from all-source data can be relayed in near-real time from vectors provided to U.S. attacking aircraft. Mission-critical information regarding updated threat, weather, or change-of-target data can be relayed in real time to the cockpit.

- Decision and Command Procedures

  Substantial improvements can be made in dynamic force management. This involves more rapid deployment of friendly forces with potential for rapid retargeting when necessary, as well as more accurate and timely BDA to ensure optimum sortie utilization. Techniques such as the "rolling frag order" show promise based on information technology and computer techniques. It will be necessary to conduct training in these technologies with actual commanders to enhance their understanding and use of triggering events.

Assumptions. Rules of engagement that permit early and aggressive neutralization of air bases will be required. Dynamic engagement/execution control of air assets must be significantly improved. Such improvement centers on more timely and effective execution of the "frag order," while maintaining the elements of centralized control. The 24-hour nature of the ATO will provide the necessary execution time for weapon loading and tanker positioning. However, the targeting and retargeting will have improved flexibility through more responsive intelligence to support "real-time information to the aircraft"or updated threat, target weather (for smart munitions delivery), and retargeting through more accurate and timely BDA. All elements of the C^2 system require these improvements.

Summary Description of the Operational Concept and Elements of the Concept. (See Figure 14.) The key elements of the concept of neutralizing enemy air bases and aircraft with at least an order-of-magnitude improvement in performance are based on several critical developments. They include the following:

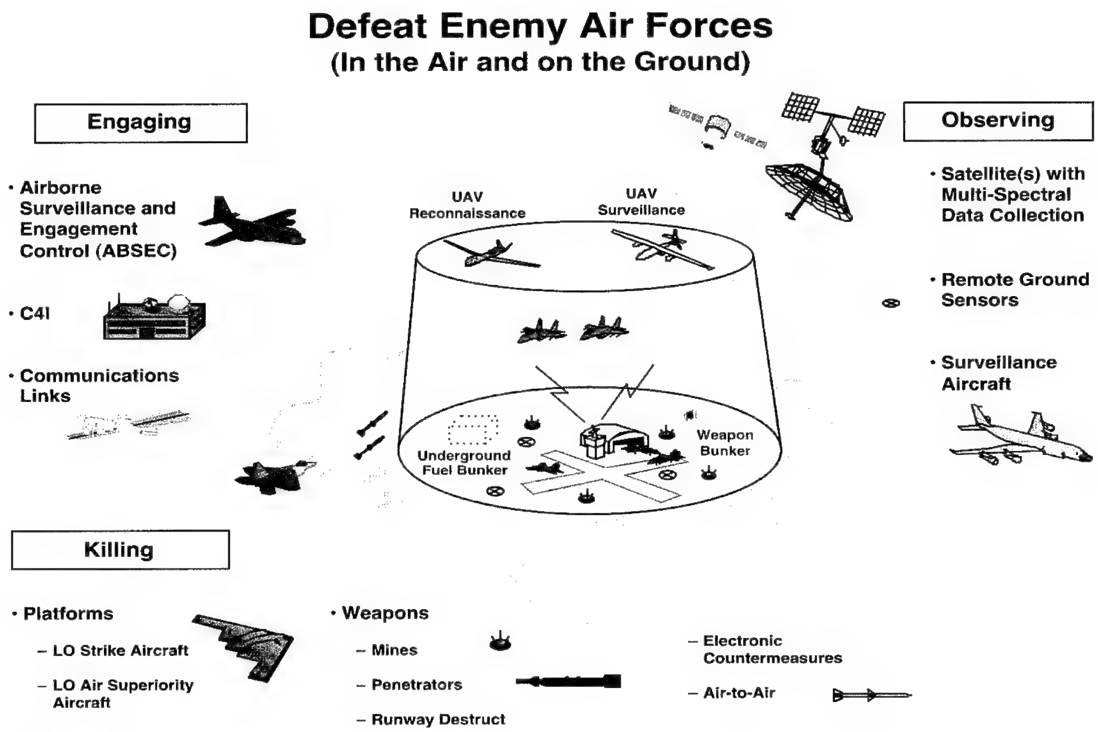

Figure 14

- Sensors to determine the intentions and location of potential adversaries should be contained within an infrastructure that provides valid triggering events. This information will enable the Air Force to operate with greater speed and accuracy compared to the enemy's observation, orientation, decision, and action (OODA) loop.
- UAVs will be developed to obtain critical tactical intelligence, including imagery and ELINT data, and to deliver accurate weapons against enemy air bases. The weapons to be delivered from UAVs have the following capabilities: crater runways and taxiways , delay repairs, disable personnel , and penetrate aircraft shelters.
- Hypersonic missiles mounted on high-altitude UAVs and manned aircraft are needed to intercept and destroy airborne enemy aircraft and UAVs.
- An air-to-air ARM should be developed and fielded for use against enemy C^3I aircraft and jammers. This will substantially improve our ability to disrupt enemy air attacks.
- Directed energy can neutralize a wide range of enemy offensive and defensive systems. Directed-energy weapons varying from HPM systems to lasers can provide necessary self-protection for our aircraft against both IR and radar defensive systems.

- SOF will play increasing roles in efforts to negate critical enemy C^2 infrastructure. The special operations capability will be employed against elements of the air base infrastructure—e.g., those supporting air base defense structure or critical command functions. Effective conduct of special operations requires technology improvements across many operations—e.g., mission planning and support, developing night-vision devices, conducting low-probability-of-intercept communications, and inserting and extracting LO aircraft vehicles.
- Accurate defense suppression is crucial to this concept. UAVs with standoff weapons and electronic countermeasures against enemy RF and IR air-to-air and SAM systems—using laser and high-power microwave energy—are necessary developments.

Capabilities and Technologies We Need

- Weapons
  - Air-to-ground weapons against air base infrastructure: runway and taxiway penetration munitions with significant "heave"; mines of various types, including antiaircraft mines; shelter penetrators; and a range of antipersonnel weapons, both lethal and nonlethal.
  - Air-to-air weapons against enemy tactical aircraft, UAVs, and C^2 aircraft: improved long-range RF and IR homing with increased electronic counter-countermeasures (ECCM) and supported by BVRID techniques. These weapons should be smaller than today's to increase the load per aircraft by a factor of two.
- Sensors for Information Dominance
  - A capability is needed to provide personnel from decision makers to shooters with situation awareness that will enable the Air Force to know the intentions of enemy aircraft. Critical elements of information (CEI) include routes of flight, type and nature of aircraft or UAVs, runway construction and supporting POL, $C^{2,}$ and shelter status. The sensors should monitor events to provide information leading to the destruction of the air base and aircraft as well as interception and destruction of deployed enemy aircraft.
- UAVs
  - The Air Force should support the development of UAVS and UTAs to complement the reduced number of manned fighter aircraft. Elements of LO technology should be included.
- Training Systems
  - A crucial capability that is achievable with emerging technology is to develop highly capable leaders and staffs who understand the critical triggering events of a broad spectrum of contingency options and who can anticipate potential events. Thus, we recommend that the Air Force enhance the development of Distributed Information Systems (DIS) in Blue Flag-type exercises.

E.8 Hostage Rsecue

Statement of the Operational Task. The United States will rescue U.S. hostages held by any nation or group at any location worldwide.

Introduction. Hostage taking is a high-leverage act of aggression against the United States and can be expected to be used by adversaries who have limited capabilities to attack our country by other means. It can occur at any time and at any location around the world. Typically, hostages will be taken to force concessions from the U.S. government. The captors will threaten harm to the hostages if demands are not met on schedule or if any action is taken to rescue the hostages or to attack any of the capturing group.

A prototype for the hostage-rescue situation is the aborted attempt to rescue U.S. embassy staff members held hostage in Iran. In this case, the hostages were taken by paramilitary captors enjoying full support from the Iranian government. In other cases, however, the captors could be nongovernmental groups such as terrorists.

Objectives. To protect our citizens and to help deter hostagetaking, the United States needs an assured capability to conduct hostage rescue. There is an imperative for high likelihood of success in these missions.

Characteristics of Targets and Environments. Hostages will typically be held in environments that are defended against attack. In the case of state-sponsored captors, this defense may include the full air defense resources of the host state. To maximize the difficulty of rescue, the hostages may be located as far as possible from an area that is safe for U.S. operations. Alternatively, to deter attack, the hostages may be detained in an urban complex surrounded by large numbers of noncombatants.

Triggering Event. The triggering event may be the hostage-taking act itself when it is done publicly. Here, the United States may have an opportunity to influence events before the hostages are removed to a well-defended location. Alternatively, the capture may not be known, in which case the United States may only be able to respond after the announcement of demands by the captors at a time when the hostages are already carefully hidden. The final triggering event for hostage rescue would be the threat of imminent harm to the hostages. The NCA (typically, the President) then makes the decision to perform a military rescue of hostages.

Assumptions. The most important action to be undertaken by the United States is to obtain reliable information on the location of the hostages. This information may be generated in many ways. Our scenario posits that, through a combination of intelligence sources, we believe we know the location of the hostages, who are under heavy guard designed to counter any rescue attempt.

- Rules of Engagement

  The goal is to rescue the hostages while minimizing collateral damage. In particular, there is a prohibition against killing or injuring noncombatants.

Summary Description of the Operational Concept and Elements of the Concept. (See Figure 15.) Shortly after the triggering event, UAVs are employed in a "cap" over the area where the hostages are being held to develop a real-time database containing information on

enemy activities and to determine the specific location. Surveillance satellites are also tasked to observe the area.

The concept for rescue centers on new SOF aircraft and nonlethal weapons. These aircraft have a radius of action of at least 750 miles at high subsonic speed, are low observable, and can each carry a squad of 12 special operations commandos and their equipment. Several such aircraft are employed—some to land the commandos and others to carry the weapons for preparing the site prior to the landing. Because of the range capabilities of the aircraft, no intermediate bases are required for the rescue operation.

The SOF aircraft employ two types of standoff weapons. One type is equipped with high-power microwave warheads designed to neutralize the communication and electric power grid networks in the area surrounding the hostage site. The other type distributes a nonlethal agent designed to temporarily disable all personnel in the selected areas.

Following the preparation of the hostage site by attacks with these weapons, the rescuers can be inserted into a relatively benign situation. Their task is to identify the exact location of the hostages. This is facilitated by microminiature transponders on the persons of the hostages that can be triggered by the rescuers.

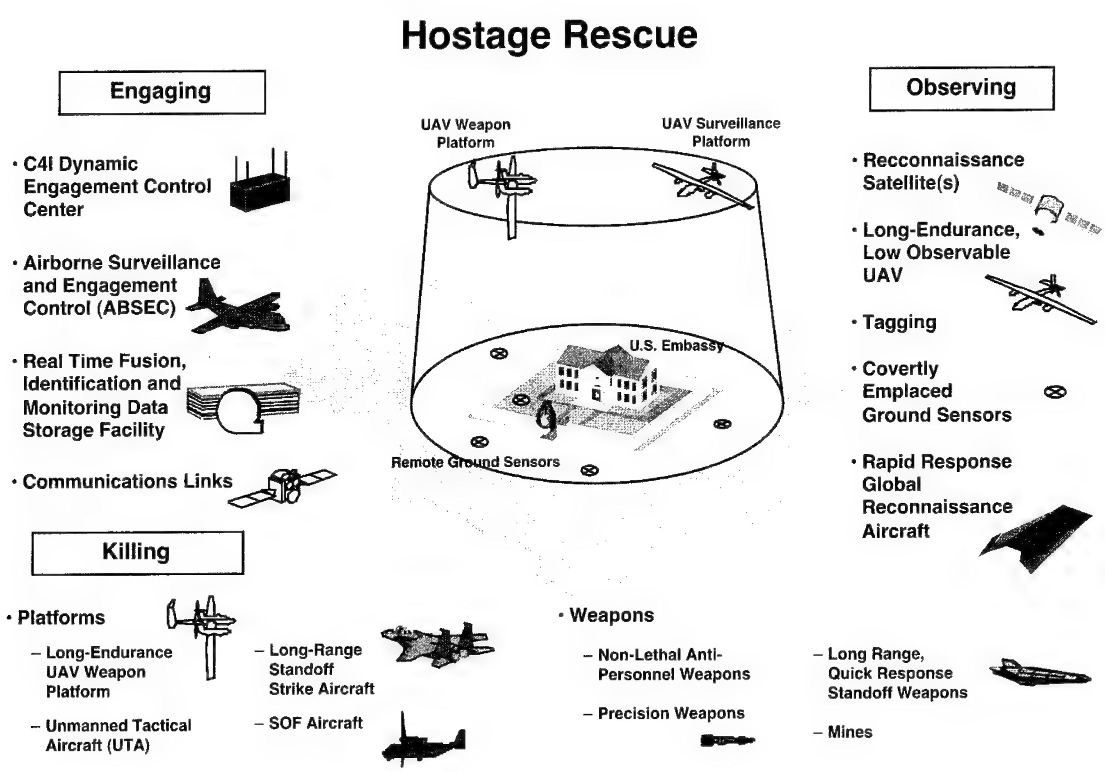

Figure 15

Capabilities and Technologies We Need

- SOF aircraft capable of penetrating to the rescue location without detection until they are within range to incapacitate the defending forces. These aircraft should be very LO, have moderate range, and operate at high subsonic cruise speeds. They must carry a commando squad and weapons and be capable of VTOL/hover at the destination.
- Microminiature RF transponders carried on/in the person of potential hostages that facilitate precision location in response to a coded interrogation signal.
- Nonlethal incapacitating weapons or other systems to prevent the defenders from responding when the commandos penetrate the structure that houses the hostages.
- High-power microwave weapons that can successfully disable communication nets and electrical power grids to isolate the area in which the hostage rescue will take place.

E.9 Provide Humanitarian Relief

Statement of the Operational Task. The United States will transport supplies, equipment, and personnel to locations world-wide to help nations and groups suffering from natural or manmade disasters.

Introduction. In accordance with national goals and values, the United States will provide food, medical care, supplies and equipment, expert personnel, and other elements of humanitarian relief to nations and groups victimized by war, famine, and other catastrophes. The Air Force will be the primary military participant in such operations through its airlift force, mobile hospitals, global communications, and other capabilities. Recent experience has demonstrated that the United States must be prepared to carry out relief missions in the face of actual or threatened hostile actions—"humanitarian relief under fire."

The following discussion is couched in terms of a stressing scenario: relief to a small enclave surrounded by undisciplined hostile forces with no conventional airfields or facilities. In keeping with the panel's overall assumption that overseas bases for use as staging areas will be limited, the Air Force can expect to deliver relief at long ranges. A concept robust enough to cope with this situation will be more than ample in more benign situations, such as a purely natural disaster in an area possessing airfields and other infrastructure.

Specific Objectives. The United States requires the ability to deliver high tonnages of diverse cargo and personnel to precise ground locations at long ranges and with minimal damage. We further require that delivery will not expose aircraft or personnel to significant risk from natural hazards, e.g., weather, or hostile action. Relief operations must be sustainable under all weather conditions and independent of airfields, navigational aids, or other facilities at the delivery location.

Characteristics of the Operational Environment. The assumed worst-case scenario involves delivery to an enclave characterized by hilly terrain, no facilities other than limited ground transportation, few and small suitable drop zones, and close proximity of hostile forces who desire to disrupt delivery and confiscate delivered material. Those forces possess

surface-to-air missiles and antiaircraft artillery and are presumed willing to use them against U.S. transports. The availability and effectiveness of SEAD forces is uncertain. The only feasible delivery method is precision airdrop from high altitude. A steady schedule of supply and equipment deliveries, with occasional drops of small numbers of U.S. personnel, must be maintained around the clock and in all weather. Navigation and precision airdrops must be autonomous because no reliable navigation aids are available in or near the enclave. Transports will fly transcontinental ranges, with aerial refueling as needed, from CONUS or from staging bases.

Triggering Event. Humanitarian relief will originate with a decision by the NCA, based on policy and an assessment of conditions in the beleaguered enclave.

Assumptions. The operational assumption is as described above. The described mission will be carried out only if threats to U.S. transports are minimal.

Summary Description of the Operational Concept and Elements of the Concept. (See Figure 16.) The concept centers on high-altitude precision airdrop using guided parasail delivery systems. This involves the following:

- Sufficient long-range transport aircraft and CONUS or overseas staging bases within refueled range of the delivery location to maintain the required daily tonnage. Transports must have self-defense systems to defeat the postulated threat. All pallets are released in a single pass to reduce threat exposure.

Figure 16

- Autonomous precision navigation through GPS-aided inertial systems.
- Precise drop zone location from stored terrain data or from surveillance by UAVs or space-based sensors, supplemented by reports from on-site personnel.
- A guided parasail airdrop system with GPS guidance and autopilot control adequate to hit precise drop coordinates in all visibility conditions and in up to moderate winds. Associated packaging must protect both bulk and delicate cargos in rough terrain landings. All pallets land within 200 feet of designated coordinates.
- If the mission must be carried out despite serious threats to transports from hostile air defenses, a SEAD package as described in Section E.3 must be employed to reduce the threat to an acceptable level at which transport self-defense systems, especially EO and RF threat warning and countermeasures, are effective.

Capabilities and Technologies We Need

- The primary development required is a complete high-altitude guided parasail delivery system, including the steerable parasail and associated pallets and packaging, guidance, and autopilot electronics, as well as rapid deployment mechanisms for the delivering transports. Such a system has been proposed by the Air Force Scientific Advisory Board, and efforts are currently underway to explore the concept.
- Advanced transports would contribute greatly to the capability to sustain a high tonnage rate in long-range deliveries.
- The acknowledged urgent need for better self protection of transports is central to the worst-case humanitarian relief scenario.
- Improved SEAD capabilities, as described in Section E.3, will be essential in dealing with hostile action encountered in humanitarian missions.

E.10 Project Power Globally

Statement of Operational Task. If an unforeseen contingency at a remote location requires an immediate response by the United States, the Air Force will be able to project highly focused and discriminate power anywhere on the globe with minimum delay from an unalerted posture.

Introduction. During the Cold War era, the USAF was focused on rapid-response power projection capabilities for an extremely constrained set of scenarios, particularly a Soviet nuclear attack on the United States or Western Europe or a Warsaw Pact invasion of Central Europe. These capabilities depended heavily on forward-deployed forces and preestablished mission plans—e.g., the Single Integrated Operational Plan (SIOP) for strategic war.

With the dramatic shift in geopolitical conditions since the turn of the decade, the threats to U.S. interests that may require very rapid-response power projection have become much more diverse and unpredictable. For example, terrorist activities may require immediate pinpoint military responses at virtually any location worldwide. The specifics of the required response may also be highly dependent on the scenario. One situation may require extreme precision weapon delivery against a fixed target. A second may require intelligence data collection.

A third may need precise delivery of emergency supplies. Furthermore, the United States can no longer depend on the availability of a network of forward bases to minimize the time and logistics burden of projecting air power into distant locations.

Specific Objectives. If a contingency emerges that the NCA determines must be addressed by the immediate projection of air power to a remote location, the Air Force must be able to mount an appropriate response using general-purpose resources that are based within CONUS or possibly at a very small number of secure sites out of CONUS. The resources must have the range and speed to accomplish the desired objectives within the time constraints of the contingency. The resources must also have the flexibility to address a wide range of possible mission functions.

In general, the capabilities for quick-response global power projection do not require large numbers of response platforms. General-purpose forces will be able to address ongoing problems, given the lead time to deploy to forward sites and set up for local operations.

Characteristics of Targets and Environments. Contingencies requiring rapid global power projection can span an extremely broad range of possible targets, environments, and mission functions. The resources necessary to perform the global power projection mission need to have a high degree of flexibility so they can be adapted quickly to the requirements of individual situations.

Triggering Event. The triggering event for global power projection can be any one of a wide range of possibilities. Some possible examples include the identification and location of a terrorist group responsible for (or preparing for) a major terrorist act, a major hostage-capture situation, or indications of preparations for an attack or invasion of a U.S. ally.

Assumptions. This discussion assumes that other resources will perform the intelligence collection and cueing functions necessary to identify the need for a global power projection action, including providing information on the precise location to which power must be projected—e.g., the geolocation coordinates of a target. This information collection may make use of a wide range of sources and methods.

- Rules of Engagement

  Many, but not all, global power projection missions will be mounted covertly to minimize the warning to opponents against which the power will be projected. However, the missions will generally not be denied after accomplishment. In most cases, the missions will be mounted from CONUS bases. With adequate security and host nation cooperation, a very few sites outside CONUS may also be feasible. Where weapon delivery is involved, global power projection missions will generally require the use of precision guided munitions with very high accuracy and minimum collateral damage. Every effort will be made to minimize the risk of losing air crews, particularly in a situation of capture for hostage purposes.

Summary and Description of the Operational Concept and Elements of the Concept. (See Figure 17). Currently, the major capabilities to perform global power projection are provided by the USAF long-range bomber fleet—i.e., B-52H, B-1B, and B-2A, supported by KC-135 and KC-10A tanker resources. Although marvelously adaptable to changing operational requirements, the B-52s are nearly 40 years old and will be increasingly restricted in the missions

they can perform. The long-range strike burden will therefore fall increasingly on the B-1Bs and the small fleet of B-2As. Supplements to this force will be desirable to address the range of possible contingency missions.

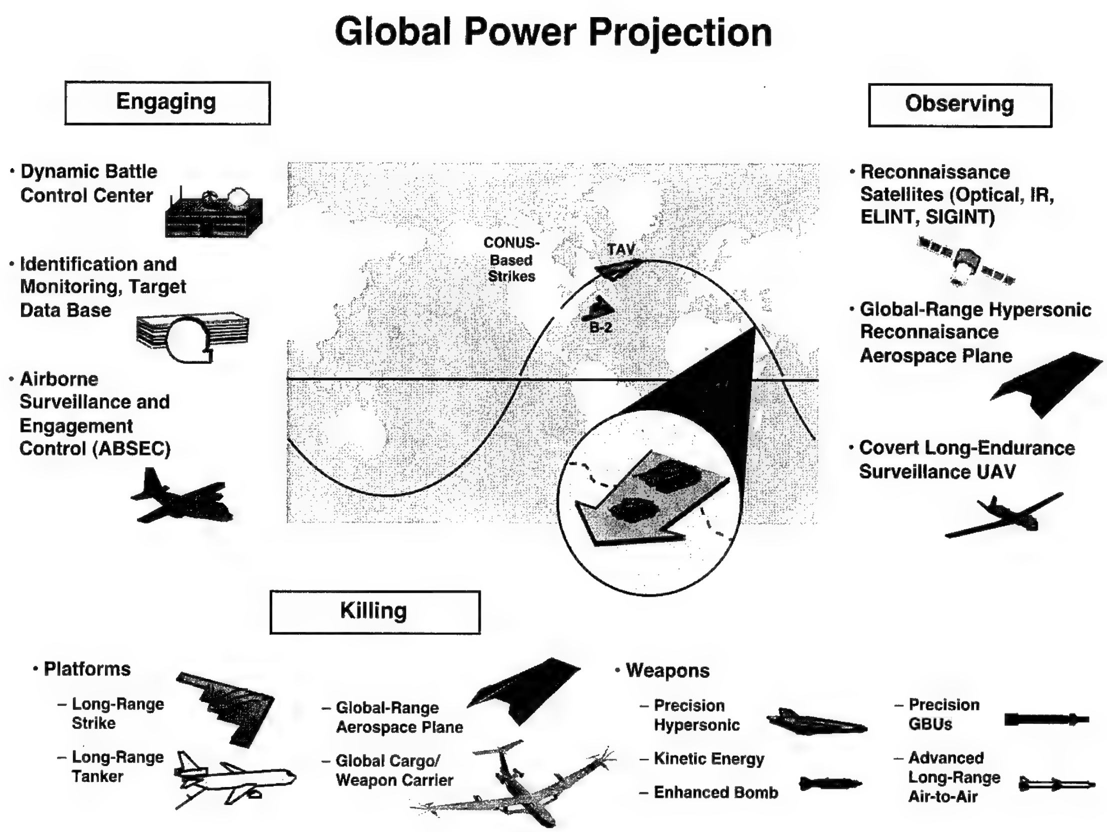

Figure 17

- One candidate system to perform the global power projection mission in the future is a global-range transatmospheric aerospace vehicle. Such a system is attractive to perform limited strike and reconnaissance missions with an extremely short flight time to the operating area. Such a vehicle would use scramjet engines to achieve high-altitude cruise above Mach 10. Much of the required technology development is a legacy of the National Aerospace Plan (NASP) program, although many technical issues remain. Innovative propulsion system concepts must be explored to determine if an affordable transatmospheric aerospace vehicle can be developed in the required time frame. One that bears investigation is the AJAX concept proposed by the Scientific Research Enterprise for Hypersonic Systems in St. Petersburg, Russia. The AJAX concept depends on extracting sufficient heat from aerodynamic structural heating to catalytically decompose water into

hydrogen and oxygen to allow the maximum possible energy extraction from conventional hydrocarbon fuels.

Transatmospheric aerospace vehicles will be expensive, both in capital cost and per-mission costs. Thus, they will be appropriate for only a limited portion of the global power projection mission. Several supplemental technologies and systems will require development to allow the use of transatmospheric aerospace vehicles, such as munitions operable at transatmospheric vehicle speeds, stores separation systems, and sensor systems for both intelligence collection and real-time targeting.

- Another candidate system to perform the global power projection mission would be a very-long-range general purpose transport aircraft configured to launch modest-sized UAVs and UTAs and recover them in flight. The large aircraft would stand off from the threat area in order to maximize its survivability. The UAVs and UTAs would be configured for the particular mission to be performed, using modular payloads that could include sensors, weapons, and supplies. As required, the UAVs and UTAs would incorporate survivability capabilities, including stealth technology, nap-of-the-earth flight profiles, and countermeasures systems.

  Air launch and recovery of manned tactical aircraft was used operationally in the late 1950s in a little-known program in which RF-84F tactical reconnaissance aircraft were carried by GRB-36 bomber aircraft. Some missions may have included deep penetration of Russian airspace prior to the employment of the U-2. In this program, the aircraft were carried semiconformally in the bomb bay of the bomber. They were launched and recovered using a trapeze assembly lowered from the bomber.

  Since that time, great advances have been made in the technology of unmanned air vehicle control and other automated systems. An up-to-date concept would use a large transport-class aircraft with a rear ramp (similar to the C-5B or the C-17A) with a robotic arm mounted at the rear of the cargo bay. The arm would move the unmanned aircraft from a storage rack in the cargo bay out into a launch position behind and below the transport. For recovery, the unmanned aircraft would fly formation on the transport in the same geometric relationship (similar to a boom-type air refueling operation). The robotic arm would be extended under the control of precision sensors and fast-response control loops to engage a connection mechanism on the unmanned aircraft and retrieve it into the cargo bay. Folding wings and tail surfaces would allow a large number of unmanned aircraft to be carried, subject to the payload–range limitations of the transport aircraft.

  This concept would make ideal use of the global range—10,000 miles or greater—transport aircraft derived from civil aeronautical technology that has been addressed in other parts of the *New World Visions* study.

Appendix F

New World Vistas In Low Observable Technology: Stealth Dominance in the 21st Century

In the past twenty years stealth—low observable technology—has emerged as a technology of enormous leverage and operational significance. The Air Force is clearly the world leader in developing and exploiting stealth technology, and the potential exists to maintain or even expand this leadership well into the 21st century. Stealth technology can make contributions to force survivability and to strategic and tactical surprise unprecendented in the history of air warfare. The performance of the F-117 during the Gulf War clearly demonstrated stealth's value, yet that was only the beginning.

The objective of stealth is to render all of the enemy's sensors—fixed ground, mobile, airborne, ship borne, missile—totally ineffective. This refers, of course, to his fielded sensors, not his theoretical, and probably unaffordable, future sensors. In the 21st century, the inevitable battle of stealth versus counterstealth systems is unlikely to center on technology. Rather, it will very likely be a battle dominated by economics. To illustrate this point: It may be technically possible to design an air defense system to defend against the next generation (post 2020) of new USAF manned and unmanned stealthy air vehicles. But how many potential adversaries will develop, produce, field, and support such systems? The cost is difficult to estimate; it will be on the order of tens of billions of dollars. The lead time will be approximately 10 to 15 years. While counterstealth will continue to be a great technical challenge, economically it may be unbearable for our future adversaries.

The *New World Vista* involves defining a strategy to field systems that at any point in time render all potential adversaries' sensors ineffective (see Figure 18). In effect, the USAF has been implementing this strategy since 1978 although it was not articulated at that time for security and other reasons. Clearly, initiation of F-117 development in 1978, B-2 development in 1981, and development of other weapons systems that exploited stealth technology were all thoroughly consistent with this unenunciated strategy. The strategy became more explicit with the initiation of the Advanced Tactical Fighter Demonstration / Validation / Prototype Program in 1985.

Future weapons systems can have radar, infrared, and other signatures that are substantially better than those of today's systems. Indeed, they may be fully capable of neutralizing sensors. (Table 4 summarizes the evolution of stealth technology in USAF air vehicles.) Among the possibilities are the following:

- Long range bombers
  - Supersonic (Mach 2–3)
  - Subsonic
- Fighter/bombers
  - Long range (1,000–1,500 miles)

- Short range (500–1,000 miles)
- Large payload (10–15,000 lbs; 10–50 precision weapons)
- Air-to-ground weapons
  - Standoff (50–100 miles)
  - Long-range standoff (100–500 miles)
- Unmanned air vehicles
  - Long range (3,000–8,000 miles)
  - High endurance (20–50 hours)
  - Short range (500–1,000 miles)
  - Multisensor (2–6 sensors)

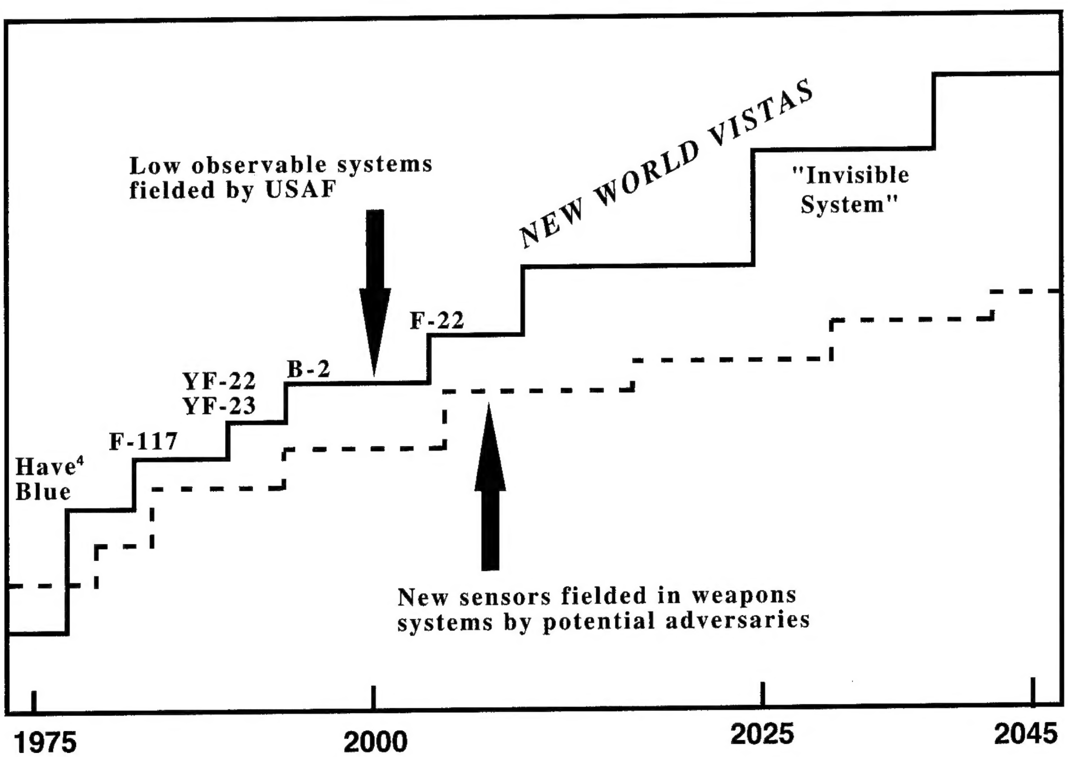

Figure 18–USAF Can Win the Stealth Marathon

4. "In April 1976, the Air Force issued a contract to Lockheed Advanced Development Projects (the Skunk Works) to produce and flight test two low radar cross section (RCS) technology demonstrator aircraft under a highly classified, special access program called Have Blue. The ensuing Have Blue flight tests validated the concept that an aircraft designed for low RCS could achieve acceptable flying characteristics as well as very low radar signatures. The success of the Have Blue flight test program led the Air Force to initiate the F-117A Full Scale Development program in November 1978."

Table 4 Stealth Technology Evolution in USAF Air Vehicles

Recent Past	**Current**	***New World Vistas***
Aerodynamic, propulsion, and weight penalties	Low performance penalties	Very low performance penalties
Radar first priority	More balanced designs	Infrared high priority
Limited analytical capabilities	Improved analytical capabilities, including low frequencies	Robust analytical and simulation capability for total RF, IR, and visual spectrum
Limited aperture technology	Extensive aperture technology	Stealthy apertures for all applications
Producibility limitations	Improved productivity	Highly producible technology
All threats not fully neutralized	Most threats neutralized	All threats defeated
Stealth not completely understood or accepted	Stealth widely accepted, but still some detractors	Stealth value indisputable-major national asset

The radar cross section (RCS) of a stealth air vehicle is controlled by the system designer. Achieving the desired low RCS over the complete frequency range of interest is not easy, but it is becoming more achievable every year. One key trend is the ability to accurately compute the three-dimensional RCS of any air vehicle design for all frequencies of interest. Another key trend is to focus on very low passive RCS over a broad frequency range and to avoid concentrating on specific current threats. The availability of super computers with parallel architectures has led to major advances in RCS analysis in recent years, and this will continue at a rapid pace. The air vehicle system designer will have the tools and technology to dominate the sensor system designer. Through vehicle shaping, materials selection, special treatments with absorbers, unique aperture technology, unique engine inlet and exhaust technology, and by exploiting the basic physics of radar, the air vehicle designer clearly has the potential to defeat current and postulated sensors. The USAF can remain preeminent in fielding low observable systems.

Controlling the infrared (IR) signature (energy emitted at wavelengths of 3–14 micrometers) is more difficult, but it is of great importance in future air vehicles because some current and many future enemy weapon systems will focus on this potential vulnerability. Here again, the air vehicle designer, in close coordination with the operational requirements staff, increasingly has the capability to control the IR signature. His tools will include very accurate analysis and simulation, careful materials selection, unique engine exhaust systems, use of special materials, and, overall, the ability to evolve a design to operationally defeat IR sensors. Once again, the basic physics is important. The key is controlling all elements of IR energy emissions by design—wavelength, three-dimensional signature geometry, and other paramenters. This must be coupled with a concept of operations which exploits the unique IR signature of the specific air vehicle.

Stealth technology has evolved rapidly in the past 20 years, and the Air Force has fielded pioneering systems which operationally exploit this technology. The first F-117A stealth fighter was delivered to the Tactical Air Command in 1982. The first B-2 was delivered to the 509th Bomber Wing in late 1993. Stealth systems add great credibility to the Air Force's Global Reach, Global Power, Global Presence strategy.

To maintain the leadership achieved in fielded low observable weapon systems over the past 20 years, the Air Force must focus on the following:

- Continue to advance and exploit the application of super-computer technology to the design of stealthy air vehicles, emphasizing the reduction and control of infrared signatures.
- Define requirements for and implement ground and airborne signature measurement systems to support the development of the next generation of USAF stealthy weapons systems. Again, IR signatures must be given higher priority.
- Vigorously develop unique materials that can be used for RF and IR signature reduction. This must include development of production technology to make these materials affordable. The industrial base in this area is marginal and has deteriorated in the past several years.
- Periodically conduct competitive vehicle-prototype programs to demonstrate integrated application of the latest low observable technology. The lesson of the Have Blue program in 1976–1978 should not be forgotten.